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FIRST REPORT OF

THE BUREAU OF MINES

1891

PRINTED BY ORDER OF THE
LEGISLATIVE ASSEMBLY OF ONTARIO.

TORONTO:
PRINTED BY WARWICK & SONS, 68 AND 70 FRONT STREET WEST.
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MAP OF PARTS OF THE DISTRICTS OF NIPISSING AND ALGOMA, EXHIBITING THE COUNTRY AROUND SUDBURY AND EASTWARD TO THE OTTAWA RIVER: Geologically colored.

FIRST REPORT OF

THE BUREAU OF MINES.

To the Honorable **Arthur S. Hardy**, Commissioner of Crown Lands :

Sir,—I have the honor to present herewith the first Annual Report of the Bureau of Mines. For reasons stated in the Introduction the Report is not as full or complete as is desirable that it should be. The subjects with which the Bureau should aim to deal require careful study and investigation, and I am deeply conscious how far the work I now submit falls short of an ideal Report. But with larger opportunities, and added knowledge and experience, I hope to make the Bureau of practical and growing service to the mining interests of our province.

I desire very heartily to acknowledge the valuable help I have received from Mr. Thomas W. Gibson, both in the performance of the office duties assigned to the Bureau in connection with mining lands and in the preparation of this Report.

A special paper by Dr. Robert Bell, of the Dominion Geological Survey, on the Geology of the Sudbury country presents in concise form the results of three seasons of field-work there. This paper and the accompanying map by the Director of Surveys, Mr. George B. Kirkpatrick, (prepared with the assistance of Dr. Bell) will it is hoped be found useful and instructive to prospectors and miners engaged in exploring and developing the mineral wealth of that region.

The second Report of the Inspector of Mines deals in detail with a number of mines and mining properties which he visited during the past year. It furnishes evidence of enterprise in the province in a number of new directions, but especially in gold and iron mining, and larger results in the present year may be looked for with confidence.

I have the honor to be, sir,
Your obedient servant,

ARCHIBALD BLUE,
Director.

Office of the
Bureau of Mines,
Toronto, March 15, 1892.

REPORT OF

THE BUREAU OF MINES.

INTRODUCTION.

The Act which created the Bureau of Mines received the assent of the Lieutenant-Governor March 4, 1891, and on the 5th of the same month an Order in Council was passed which transferred me from the office of Deputy-Minister of Agriculture to the office of Director of the Bureau of Mines.

It became necessaay to enter upon the duties of the new position at once, but I continued to devote a portion of the time to the requirements of the old one until the appointment of my successor in June.

In the same month Mr. Thomas W. Gibson was appointed as clerk and shorthand writer in the Bureau, but he was also assigned certain duties in the Woods and Forests branch of the Department of Crown Lands. Mr. Gibson's former connection with the Department as secretary to the late Hon. Mr. Pardee gave him an experience which has proven of valuable service to the Bureau.

The increase in the volume of work of the Department of Crown Lands made it desirable that some readjustment should take place in connection with the sale of public lands, and accordingly it was arranged that transactions in mining lands in surveyed territory should be assigned to the Bureau of Mines. Unsurveyed territory was left as heretofore under the Director of Surveys—the Mining Act requiring that the plan, field notes and description of each location in unsurveyed territory be furnished so that it may be laid down on the office maps of the Department.

The provisions in sub-section 5 of the first section of the Act of 1891, whereby mining lands in certain cases might be obtained at the price and upon the conditions prescribed in the old Act, imposed a load of labor upon the Bureau at the outset. Many of the claims under this sub-section were of an intricate character, and evidence and information on many points had to be procured before they were ready to be cleared off. For this reason there was not much time left for undertakings which call for the visiting of districts in which minerals are found or in which mining operations are carried on.

Foreseeing that in the time at my disposal I could not hope to visit all the mining districts before the end of the year, I decided to confine my enquiries as far as possible to fields not covered by the Inspector of Mines, hoping that in this way the whole ground might be fairly gone over. In one instance only were visits to the same localities duplicated, viz: the gypsum mines on the Grand river. Having seen those mines in the month of November, and being impressed with the unsafe condition of some of them, I advised the Inspector to examine them and make an official report as called for by the Act respecting Mining Regulations.

In July I spent a number of days visiting the stone quarries and cement works along the mountain between the Niagara river and Hamilton, and at intervals in September and October the quarries along the escarpment from Hamilton to Owen Sound, the pressed brick and terra cotta works at Campbellsville and in the vicinity of Milton, and the Portland cement works in the township of Keppel, county of Grey.

The greater part of August was occupied in a visit to the Lake of the Woods district, when a journey was made to the head of the lake and up the Rainy river to Fort Francis and Rainy lake, and afterwards to Crow lake. Several gold locations were examined, but at that time only one was being worked. Since then greater activity has been displayed in this district and considerable quantities of gold-bearing ore have been taken out, as a result it is believed of the reduction works which have been erected at Rat Portage. These works were almost completed at the time of my visit and one or two test runs were made, one of which I witnessed. It is understood that they have since been improved and new machinery added, and hopes are entertained that this year they will be kept busy treating Lake of the Woods ores. Two or three stamp mills are also in course of erection, one at the Gold Hill mine south of Rat Portage and one at a location on the Canadian Pacific Railway a few miles east of the town. The reduction works will no doubt greatly aid in demonstrating the value of the gold ores in this region. Other promising gold districts upon which some development work was done last year are on the Vermilion river, west of Sudbury, and in the township of Belmont, in the county of Hastings. A report on a mine and new reduction works in the last named district is made by the Inspector.

In September the gas-producing district in the southern part of the county of Essex was visited, and to gain further information on this valuable fuel and the uses to which it is applied I spent a short time in the Findlay gas field in the state of Ohio. In the following month a couple of weeks were occupied in getting information upon the gas fields in the counties of Welland and Haldimand, where a number of wells have been bored and large flows of gas obtained, and in collecting facts on the existence of surface gas in the lake shore townships of the county of Kent.

The gypsum mines in the counties of Brant and Haldimand were visited in November, as also the salt regions in the counties of Huron and Lambton. In the following month I spent a few days in Frontenac, Lennox and Hastings, visiting among other places the Portland and natural rock cement works at Napanee Mills.

To collect and publish information and statistics on the mineral resources and the mining industries of the province will be one of the chief objects of the Bureau of Mines. Important discoveries are being made every year, and no doubt much of our wealth yet lies hidden in the earth. The deposits of iron ore on the Atik-Okan and Mattawan rivers, which are believed to be of vast extent, have for the most part been discovered within the last two years. The nickel ores of the Sudbury district were unknown six years ago, and during the past year many large and rich finds have been made. Promising gold leads have been found at various points between the Thessalon river and Temagami lake, as well as in the county of Hastings. Extensive beds of kaolin are now known to exist on the eastern and western tributaries of the Moose river, the Abittibi and Missinaibi, valuable for the manufacture of fine pottery, and perhaps more valuable still for the production of aluminium, a semi-noble metal that seems likely to become almost as useful in the arts as iron itself. Then it is only four years ago that we became conscious of having a clay suitable for the manufacture of pressed brick and architectural terra cotta of the very best quality, and we know now, what was not suspected at first, that a bed of it in the Medina formation is 400 to 600 feet in depth and lies exposed for more than a hundred miles within easy reach of the principal cities of the province We know also that a lower formation (the Hudson River shales), upon which the city of Toronto stands, yields a clay which, if that be possible, is even superior to the Medina; but no one thought of experimenting upon the Hudson River shales for this purpose until a year ago. What the possibilities are for procuring natural gas no one is so bold as to conjecture. It has been demonstrated to exist in great volume in the Medina sandstone in the counties of Welland and Haldimand, and in the Clinton limestone in Essex, and three or four days ago a good flow is claimed to have been struck in the Trenton formation within a few miles of Toronto.

In this way we are being treated to a succession of surprises, and the work of prospecting the province for minerals has been scarcely begun as yet in a systematic and intelligent way. The Bureau of Mines has therefore a large field to occupy even if limited in its scope to the recording of progress and discovery alone. But the aim will be to deal with progress and discovery in the widest sense, and in the most practical way, in relation to geology, mineralogy and metallurgy, without which the Bureau would be of little service to its purpose as defined by statute, viz: "To aid in promoting the mining interests of the province."

Annual statistics of production are of the first importance, as without them we cannot know definitely the state and progress of an industry, nor the directions in which it may be moving, nor the effect produced upon it by legislation or public policy, nor the parts of it which are weakest and most in need of help and care. Statistics are to industry what pulse and temperature are to the human body; they enable us to observe symptoms and study conditions, and in an intelligent way to suggest and apply remedies when remedies are needed. And so the collection of mineral statistics will be made a prominent feature in the scheme of the Bureau.

The initial difficulty in gathering the mineral statistics of the province is to procure a full list of companies, firms and persons who are engaged in the mining industry, and especially of those engaged in the quarrying and manufacture of structural materials. Mines of the metallic ores, as well as of gypsum, mica and phosphate of lime, besides being comparatively few in number are required to be regularly visited by the Inspector of Mines, and little trouble is experienced in getting returns from these. There are also only a few salt, cement, pressed brick and terra cotta works in the province, and they are well known; but their statistics come in only in response to line upon line of effort and persuasion. The returns which have been obtained, however, are pretty full and complete. Stone quarries, brick and tile yards and lime-kilns are so numerous that a correct list of them cannot readily be made up, and the statistics of these works presented herewith are only estimates based on the returns which have been received.

Following is a summary of the quantity and value of mineral production in the province for the calendar year 1891, together with the wages paid for skilled and unskilled labor:

From eighty-four stone quarries was taken about $1,000,000 worth of building stone (including dimension stone, heads and sills, coursing stone and rubble), the labor upon which is computed at $520,000.

Five cement works manufactured 48,211 barrels of cement, valued at $44,501, at a cost for labor of $23,400. In this output is included 2,033 barrels of Portland cement, valued at $5,082, the first of this kind of cement produced in Ontario in commercial quantities.

One hundred and thirty lime-kilns burnt about 2,350,000 bushels of lime, valued at $300,000; the labor charge of which was $116,000.

Two hundred and fifty yards produced about 160,000,000 common brick, valued at $950,000, at a cost for labor of $400,000.

Seven establishments produced 12,647,909 pressed brick, 570,000 fancy brick, 400,000 roofing tile and a quantity of ornamental and porous terra cotta, the whole valued at $156,699. The cost of labor was $58,000.

Sixty yards manufacturing drain tile produced about 7,500,000 tile of various sizes, valued at $90,000; total wages for labor, $32,000.

Three sewer tile works turned out a quantity estimated at 1,375,000, of the value of $270,000, and at a cost for labor of $38,000.

Thirty pottery works produced ware to the computed value of $45,000.

Six gypsum mines yielded 5,350 tons, valued at $12,200, at a cost for labor of $5,500.

Eleven phosphate mines yielded 4,900 tons, valued at $50,800, the amount paid for labor being $29,500. Owing to a fall in the market price these mines were worked for only a short time and with a small force.

Seventeen salt works produced 44,167 tons of salt, valued at $157,000.

Four mica mines yielded 240 tons, more than one-half of which was sold in the raw state. The total value of raw and manufactured product is returned at $31,200, and the amount of wages paid for labor was $14,262.

The product of eight nickel mines operated by four mining companies was 85,790 tons, returned at the low valuation of $324,240. The total amount paid for labor was $322,201. These returns of course do not include labor for roasting and smelting the ore, nor its value when converted into matte. Of the latter product the United States government last year purchased for armour plate purposes 4,536 tons, containing about 900 tons of nickel.

Four silver mining companies have made returns of 14,925 tons of ore, valued at $64,475, with total cost for wages of labor of $100,278. Like nickel, the valuation of silver ore is made very low, being nearly $30,000 less than the sum paid for wages.

Gold mining was confined almost wholly to prospecting work, but about 2,000 tons of ore were raised. Operations were carried on upon two locations in Hastings, one in the Sudbury district and four in the Lake of the Woods region. Quantities of the ore were treated with apparently satisfactory results.

Iron mining was also of a prospective character only, the total quantity raised being about 200 tons. Explorations made with the diamond drill in the township of Belmont and on the Mattawan and Atik-Okan rivers are claimed to have demonstrated the existence of large bodies of excellent iron ore in those localities. It seems likely that a good start will be made on one of these properties during the present year.

The petroleum output is computed from the railway shipments of crude and refined from the oil district, the refined being given at its crude equivalent, and the value is calculated from averages of weekly quotations and the monthly shipments. The total output was 894,647 barrels, valued at $1,209,558.

The following table presents the mineral statistics of the province for the year 1891, giving (1) number of mines or works, (2) quantity of product, (3) value of product, (4) average of weekly wages for skilled and unskilled labor, and (5) total cost of wages :

Product.	No.	Quantity.	Value.	Wages of labor.		Total wages.
				Skilled.	Unskilled	
			$	$	$	$
Building stone..........	84		1,000,000	9.00*	7.00	520,000
Cement	5	bbl. 48,211	44,501			23,400
Lime	130	bush. 2,350,000	300,000	8.65	5.90	116,000
Common brick..........	250	no. 160,000,000	950,000	11 25	8.00	400,000
Pressed brick, roofing tile and terra cotta....	7	no. 13,617,909	156,699	12.60	8.00	58,000
Drain tile	60	no. 7,500,000	90,000			32,000
Sewer tile	3	no. 1,375,000	270,000		8.50	38,000
Pottery	30		45,000			
Gypsum....	6	ton 5,350	12,200	9.30	7.30	5,500
Phosphate............	11	ton 4,900	50,800		6.00	29,500
Salt..	17	ton 44,167	157,000			
Mica...........	4	ton 240	31,200	7.60	6.85	14,262
Nickel	8	ton 85,790	324,240	11.70	7.40	322,201
Silver	4	ton 14,925	64,475	13.50	12.00	100,278
Petroleum, crude		bbl. 894,647	1,209,558			

*This is for quarrymen. The average wages of stonecutters per week was $18.66.

The total value of mineral production for the year, as shown by this table, was $4,705,673, and the cost of labor exclusive of petroleum, salt and pottery was $1,659,141

OPERATION OF THE MINING ACT.

The Mining Act as amended by the Act of last year did not come into effect until the 4th day of May. Its chief new features are:

1. Increase in the price of mining lands;
2. Option to take up lands under leasehold or fee simple; and
3. Provision to impose royalties on ores or minerals.

SALE AND LEASE OF MINING LANDS.

The price of mining lands under the old Act in the districts north of Lake Nipissing and the French and Mattawa rivers was uniformly $2 per acre, and in districts south it was $1 per acre.

Under the amended Act prices are graduated according to the situation of lands with respect to railway lines and surveyed territory, ranging from $3 to $4.50 per acre in the districts north and from $2 to $3 in the districts south of Lake Nipissing and the French and Mattawa rivers.

But the new Act also contains a provision which enabled parties who had made application under the terms of the old Act and paid in money thereon, or who as prospectors or explorers had applied for and expended money or labor in proving locations, to acquire lands at the old price and free from royalties and working conditions, upon renewal of application and payment of the purchase money.

The following table shows by districts the area for which patents in fee simple were issued and the amount paid therefor into the treasury of the province for the year ending December 31, 1891:

District.	No. of patents.	Acres.	$.
Rainy River	46	6,812	14,020
Thunder Bay	72	17,172	34,936
Algoma	130	29,580	59,519
Nipissing	20	3,364	6,349
Parry Sound and Muskoka	4	365	365
Elsewhere	17	2,096	2,325
Total	289	59,389	$117,514

Under the leasing clause parties may acquire mining lands in the districts north of Lake Nipissing and the French and Mattawa rivers at the rate of one dollar per acre for the first year and twenty-five cents per year thereafter, and in districts south of those waters at sixty cents per acre for the first year and fifteen cents per year thereafter.

This feature of the Mining Act is a novel one in this province, and in view of the tenure which so generally obtains in Canada and the United States leasehold from the Crown can only be regarded as on trial. So far it has been favorably received by all classes of mining men, as a large proportion of the applications for lands now being received are made under the terms of the leasing clause. Should it for any reason prove unsatisfactory to the holders they are free to change the tenure into fee simple, in which case the payment of the first year's rent would be applied on the purchase money.

In the state of Minnesota the leasing system was adopted three years ago, and is *reported* as working very satisfactorily alike to leaseholders and the state. In the Australian colonies and New Zealand all mining lands are leased, and the rental is a fixed one ranging from five shillings to twenty shillings sterling per acre for each year of the term.

The following table shows by districts the area of mining lands for which leases were granted last year under the terms of the new Act, and the amount paid into the treasury for the first year's rent:

District.	No. of leases.	Acres.	$.
Rainy River	2	129	129
Thunder Bay	11	1,267	1,267
Algoma	14	1,793	1,793
Nipissing	17	1,529	1,529
Parry Sound	2	205	123
Elsewhere	1	75	45
Total	47	4,998	$4,886

At the present date (March 15, 1892) thirty more leases are ready for execution covering an area of 3,500 acres.

ROYALTY ON ORES AND MINERALS.

The royalty provision has been more severely criticised than any other of the amended Act. It is, indeed, the only one to which strong objection has been taken, and many sins have been laid at its door by the opponents of the clause. But the subject has more than one side, and there has been much misrepresentation.

It has been charged, for instance, that the royalty has destroyed mining operations in the North Shore districts and driven capitalists and miners out of the country.

This assumes that the clause is already in force, and that it affects alike all mining lands, whether the title is in or out of the Crown. The facts are that it does not apply at all to any lands patented previous to the 4th of May, 1891, saving lands patented under the Free Grants and Homesteads Act; and it cannot apply to any lands sold or leased after that date until seven years from the issue of the patent or lease except in the case of mines known to be rich in nickel, and as to these it cannot apply for four years. Moreover, the imposition of royalty could not be made retroactive, as has been shown by the attitude of the Minister of Justice towards the royalty clause of the Quebec Mining Act.

It is true that mining has been comparatively slack during the past year, but not in Ontario or Canada alone. In the United States and Great Britain there was a serious depression as an immediate consequence of the failure of large banking houses in both countries in the latter part of 1890 and the beginning of 1891. The falling off in the tonnage of Lake Superior iron ore in 1891, compared with the output of 1890, was greater than the tonnage of all the iron ore ever raised in the province of Ontario, if not in the whole of Canada.

In Great Britain inactivity continued throughout the year, but in the United States the industry revived in the last six months as a result of the good harvest in that country.

In Canada, and especially in the province of Ontario, we are dependent on foreign capital to open up and work our mines of iron, nickel, gold, silver, phosphate, etc. Our own capitalists are shy of such investments. Except in rare instances they cannot be persuaded to put their money into mines, or blast furnaces, or reduction works, or refining works, or rolling mills. Enterprise of this sort is a thing of growth and education, and inasmuch as hitherto we have had to rely upon British and American capital to buy and develop our mining lands it can readily be perceived how the financial failures of 1890-91 would affect mining operations in our country.

For more than twenty years miners were free from the payment of royalties to the Crown in Ontario, yet during that period the industry did not prosper. Silver mining was stirred into activity at one time, as an indirect consequence of the policy of putting a provincial tax on mining lands, but the iron, copper and gold mines were idle, and the phosphate and gypsum mines were worked intermittently, in a half-hearted way. We had neither capital nor skill to operate them, and the abolition of the royalties does not appear to have offered a new inducement to one or the other.

The discovery of nickel ore in vast quantities in the North Shore districts a few years ago, and the more recent discovery of the value of nickel as an alloy with steel, have done more than anything else to attract attention to the mineral resources of our province, and there is no evidence to show that the royalty clause of the amended Act has kept out skill or capital in so far as this ore is concerned. It probably did interfere with the plans of dealers, some of whom made fortunes by the sale or lease of undeveloped properties acquired under the terms of the old Act, and all of whom were sanguine of making larger fortunes had the Legislature not seen fit to consider the share of the public interests in that portion of the Crown domain as something apart from the interests of individuals.

A boom has been arrested, but not a mining boom. The men who complain most persistently of the Crown royalty are not miners or mining companies ; they are persons who lived in expectation of becoming "kings" themselves, with miners and mining companies paying royalty dues to them.

I have in mind one case in which an option sale of three small locations of nickel ore, situated eight or ten miles from a railway, was made to an English syndicate for a consideration of about $120,000 and a royalty of twenty-five cents per ton on a daily minimum of 200 tons of ore. A payment of several thousand dollars was made on the purchase and as much more was spent in exploring the property last summer, when the representative of the syndicate came to the conclusion that the price agreed upon was far too high in view of the terms upon which locations might be procured from other parties or from the Government. An effort was then made to buy the locations from the owners free from royalty terms, but the price demanded (a quarter of a million dollars) led the syndicate to abandon its option, and meantime they have withdrawn from the country.

Numerous instances of this kind might be cited, and there is no doubt but that the system of private royalties is in great favor with mineral land owners of speculative tendencies.

The iron locations on the Atik-Okan river, fifty miles from the nearest railway station, are understood to have been optioned to a Belgian syndicate subject to royalties ranging from twenty to twenty-five cents per ton ; another location in Hastings county has been leased subject to a royalty of forty cents ; a barytes mine in Lake Superior is leased at twenty-five cents, and a phosphate mine in the eastern part of the province at two dollars per ton, with a fixed minimum output in each case.

It would be easy to lengthen out the list if it was necessary, for the plan of making mineral land a source of revenue to the owner suggests itself naturally ; it is the all but universal practice in Great Britain and the United States, as I shall show presently.

Now the rates of royalty provided for in our Act are on a more moderate scale, being three per cent. on silver and copper and nickel, not exceeding two per cent. on iron, and not exceeding three per cent. on all other ores of metals, calculated upon their value at the pit's mouth.

We do not know exactly what this value would be upon the several kinds of ores in Ontario, but in the case of iron ore we have the data furnished by Bulletin 113 of the United States census for 1890, showing the cost of production in the various states and of the value put upon the ore at the mines, based on the output of 1889. The following table gives the figures for a few states and the whole country, computed for the long ton.

States.	Cost per ton.	Value per ton.
	$	$
Alabama	0.82	0.96
Michigan	2.07	2.70
Minnesota	1.80	2.87
New Jersey	2.74	3.23
New York	1.64	2.49
Pennyslvania	1.10	1.96
Wisconsin	1.78	2.20
United States	1.71	2.30

For the short ton these averages of cost and value would be about one-ninth less, so that the value of ore at the mines of the United States in 1889 was $2.05 per short ton, in Michigan $2.40, in Minnesota $2.55, in New York $2.21, and elsewhere in the same proportion.

On this basis the royalty payable to the province would not exceed five cents per ton as against the royalties of twenty, twenty-five and forty cents per ton which by the terms of contracts are payable to private parties for iron ore.

For the ores of nickel and copper and of silver we have the returns of values made by mining companies to the Minister of Agriculture for the years 1890 and 1891, as required by the Mining Operations Act. These give averages of $7.60 per ton for nickel and copper and $15 for silver per ton, which at the rate provided for in the Act would yield a royalty of about twenty-three cents on the former and forty-five cents on the latter.

In the light of these figures it is perhaps not surprising if the private owners of mining locations should view with a jealous eye the conduct of the Government in reserving a small royalty on ores or minerals taken from lands sold or leased under the amended Act, at the low price fixed in the Act.

I turn now to deal briefly with the practice followed elsewhere in the matter of royalties, and the disposition made of the public interest in mineral lands.

NOVA SCOTIA.

The law relating to mines and minerals in Nova Scotia provides for the issue of licenses to prospect, search and work lands for ores or minerals, for the leasing of lands at a rental, and for royalties upon ores or minerals removed from the mines.

On all leases of gold mines there is reserved a royalty of two per cent. upon the gross amount taken out, and upon coal the rate since 1885 has been seven and one-half cents per ton of 2,240 lb. Other royalties are provided for, but gold and coal are the only minerals which yield a revenue.

The following table shows the revenue of the province from mining rents, licenses and royalties, together with the revenue from all sources, for the seven years 1884-90:

Year.	Rents.	Licenses.	Royalties.	Revenue from all sources.
	$	$	$	$
1884	2,101	5,267.99	91,804.01	586,561.55
1885	3,596	6,726.60	108,033.16	613,026.27
1886	3,248	12,315.71	109,977.34	633,145.43
1887	4,212	13,320.81	126,930.78	656,639.11
1888	4,388	14,383.62	132,134.52	712,951.49
1889	6,325	22,795.58	137,399.36	713,941.82
1890	5,327	25,197.02	138,120.27	710,497.38
Totals	29,197	100,007.33	844,399.44	4,626,763.05

The revenue from licenses, rents and royalties in the seven years was an average of

21 per cent. of the revenue from all sources, being in the first three years of the period 18⅔ and in the last three years nearly 23 per cent. of the whole.

The revenue from royalties alone in the seven years was an average of 18¼ per cent. of the revenue from all sources; for the first three years of the period 17 per cent., and for the last three years 19 per cent. of the whole.

Licenses and royalties show a continuous yearly increase, and rents an increase for every year but one. It will be observed also that the ratio of revenue from these sources to the total revenue of the province shows a constant increase.

The other most important source of the yearly revenue of Nova Scotia is the subsidy and interest paid by the Dominion, which is now about $433,000.

THE UNITED STATES.

The way in which the Government of the United States regards mineral property in public lands was very fully stated before the British Commission on Mining Royalties last year by Dr. R. W. Raymond, secretary of the American Institute of Mining Engineers. The Federal Government, Dr. Raymond said, never has exercised anything like the ancient right of sovereignty in the metals. The first cause of this fact, he explained, was the nature of the Federal Government when it was first established by the thirteen original states.

> "Those states were colonies of Great Britain. They had all of them received by royal grant, in one form or another, a delegated sovereignty in the metals. That sovereignty at that time was much more extensively asserted by the English Crown than it is to-day, and its rights were given by the Crown in the original grants to the colonies, subject to certain royalties to be paid back to the Crown. The colonies were, in fact, concessionaires or sub-lessees under the grant of that sovereignty. When their independence was established at the end of our revolutionary war, and recognised by treaty, the separate colonies succeeded to all the rights of sovereignty which Great Britain had resigned. In forming their federal union at the end of the last century they created the constitution of the United States, which is solely an instrument of positive grants. . . . All the rights not ceded by the original states to the Federal Government were reserved to the states, or to the people thereof, by express reservation in our constitution. Now there never was any right of sovereignty in the metals so ceded by the states to the general government. Certain rights were given, but the right of sovereignty in the metals was not given, and as a matter of fact the original states have gone on since that time asserting that right and exercising it, although the laws by which they exercise it are mostly dead letters."

Upon the discovery of lead and copper in some of the western and north-western states Congress put into the hands of the Secretary of the Treasury the matter of mining on those lands and authorized him to lease mining rights, making concessions upon royalties. This experiment went on for about forty years with varied attempts to rectify the abuses and confusion which grew up, but it was finally abandoned, and it was the last attempt of the Federal Government to do anything with its mineral lands except to sell them in the old fashioned English way, top and bottom going together.

> "A patent of land from the United States," according to a decision of the Supreme Court quoted by Dr. Raymond, "passes to the patentee all the interest of the United States, whatever it may be, in everything connected with the soil or forming any portion of its bed, or fixed to its surface; in short, everything embraced within the term 'land.'"

The patentees being therefore unqualified owners of the land and all that it contains are free to dispose of it as they see fit. If ore or mineral of any kind is found upon or under the surface, the owner may work it, or sell it for another to work and take it away, or lease it upon a royalty. The latter practice prevails widely in many states, especially as regards deposits of coal and iron ore. Sometimes the land is sold outright to a mining company, as in the case of a sale of coal lands to the Reading Railway Company for $50,000,000, mentioned by Dr. Raymond; but the interest on the purchase money is the equivalent of a rental or a royalty. On private lands the royalty charge on bituminous coal ranges from five to twenty-eight cents per ton, the average being about fourteen cents; on anthracite coal it ranges up to sixty cents, but the average may be between thirty and forty cents.

The census of 1880 shows that royalty was paid to private owners on more than one-quarter of the iron ore product of the United States in 1879, the average being 43.7 cents per ton of 2,000 lb., or 48.9 cents per long ton. The total quantity upon which royalty was paid was 2,334,524 tons, while the total of iron ore raised in the census year was 7,974,806 tons. The following table shows for four of the principal states the number of tons upon which royalty was paid, the range and average of royalty per ton, and the total amounts paid:

States.	Tons, 2,000 lb.	Range of royalty.	Average of royalty.	Total royalty.
		cts.	cts.	$
Michigan	392,251	31 to 76	43.88	172,145
New Jersey.............	364,945	22 to 89	54.46	198,391
New York..............	191,415	13 to 89	38.40	73,496
Pennsylvania	972,862	13 to 108	45.44	442,067

The report on iron ore for the census of 1890 by Mr. John Birkinbine, as published in Bulletin 113, is not so definite as the report of 1880 on the amount paid for royalties in 1889. The total output of iron ore that year was 14,518,041 long tons. After giving expenditure for wages, supplies and materials of all kinds and for contract work, Mr. Birkinbine says:

> "Other expenditures include taxes and royalties amounting to $3,795,509. As royalty is only paid on a portion of the ore mined, and as the system of owners charging up a rate per ton against the mine as a sinking fund does not prevail to any extent, it would be unfair to form any conclusions as to the average royalties, namely, so much per ton, on the basis of the reports made."

But he also states that "in the Lake Superior region a large proportion of the mines are leased, and in other districts mines are worked under leases, a stipulated sum per ton, with a minimum yearly royalty provision, being paid to the owners of the fee."

MINNESOTA, WISCONSIN AND MICHIGAN.

The provisions of the mining laws of the United States do not apply to mineral lands held by the Federal Government in the states of Minnesota, Wisconsin and Michigan, which by the Act of 1872 were declared to be free and open for exploration and purchase in the same manner, at the same price and under the same rights of pre-emption as other public lands. That is to say, all Federal lands in those states are subject to the laws which have been enacted for agricultural lands.

When part or the whole of a township is surveyed, the lands are divided into three classes, viz.: school, agricultural and swamp lands. All wet lands are returned by the surveyor as swamp lands, and are by law ordered to be patented to the state. Grants of agricultural lands to the state are also provided for under special Acts of Congress, and the proceeds of sales are applied to the objects of the grants.

Through the operation of those laws and grants the states above named have come into possession of valuable deposits of iron and other ores, and various plans have been tried with a view to advance the mining industry and guard the interests of the people.

In Minnesota provision for a state revenue from corporations organized to carry on the business of mining, smelting or refining copper or iron ores was made by an Act of the Legislature in 1881, whereby such corporations may pay into the state treasury annually in lieu of all taxes or assessments upon their capital stock, personal property, income and real estate a special tax at the following rates, viz: On each ton of copper fifty cents, and on each ton of iron ore mined and shipped one cent per ton, each ton to be estimated at 2,240 lb. One-half of the taxes so paid are credited to the general fund of the state, and the other half to the county in which the mines are located. Where corporations do not accept these provisions of assessment it would appear that they are liable to pay rates for municipal and state purposes in the same way as other owners of property.

Until 1889 lands containing minerals were disposed of in the same way and upon the same terms as agricultural lands, but in that year a new law was enacted by the Legislature which had in view the prospective revenue of the state. Under this law the Commissioner of the Land Office is authorised to execute leases and contracts for the mining and shipping of iron ores from any lands belonging to the state, subject to the following conditions:

1. The area covered by any one lease is limited to 160 acres of contiguous descriptions, but before a lease is granted the applicant is required to pay therefor the sum of $25. The holder may prospect for iron ore on the lands embraced in his lease for one year, and at any time prior to its expiration he has the right to obtain from the Commissioner a contract for a term of fifty years, binding the state and the lessee in a mutual observance of its obligations and conditions.

2. The contract provides for the payment of an annual rent of $100 up to the time when the first 1,000 tons of ore is mined and removed, and the lessee is bound within five years from the completion of a railroad within one mile of the land to remove at least 1,000 tons of ore therefrom, and at least 5,000 tons each year thereafter, paying therefor to the state a royalty of 25 cents per ton quarterly, the minimum of royalty being fixed at $1,250 whether the ore is raised and removed or not. The lessee also agrees to pay all taxes assessed against the lands, its improvements and product, just as though the property leased was owned in fee.

3. If the royalty remains in default for sixty days, or if the lessee fails to keep the conditions of the contract, the state may take possession of the premises; but the lessee has the right at any time to terminate the agreement upon sixty days' notice, and is allowed ninety days in which to remove all engines, machinery, railroad tracks and structures placed on the land.

The Act provides also that should copper or other valuable mineral be discovered on leased land the conditions on which it may be mined are subject to agreement or reference, and the Commissioner is empowered to reserve to the state all mineral rights on state lands sold or leased in those counties in which minerals are known to occur.

During the first year of the operation of this law 153 leases were issued and applications were received for over 600, the major portion being for the purpose of exploring for iron ore.[*]

In Wisconsin certificates of sale of public lands do not bestow the right to take the minerals. That right depends on obtaining the written consent of the Commissioner of Public Lands. Provision is also made by statute for the leasing of private lands for mining purposes by their owners, and payment of royalties by miners is very general.

In Michigan mining lands which are the property of the state are sold after valuation by state officers, and until recently minerals were subject to a specific tax in lieu of all other state taxes except taxes on capital stock. In 1890 the revenue from this specific tax on copper, iron ore and coal was in round numbers $110,000, but in the season of 1890-91 the Legislature repealed this tax and mines are now assessed at their real value and subject to the same rate as all other kinds of property for state purposes.

The price of mining lands last year ranged from $4 to $30 per acre according to locality, but while no royalty is reserved by the state there are many mines in which tribute is paid to the private owners. On this subject the Commissioner of Mineral Statistics made the following remarks in his report for 1885 :

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[*] Referring to the operation of this law the Duluth Herald reports a recent interview with Mr. George C. Stone as follows: "Some two or three years ago I conceived the idea that the state would do better by withdrawing all her mineral lands in the Mesabi and Vermilion ranges from sale and leasing them on terms that would not hinder their development. And so a law was passed in accordance with a plan outlined by myself. This is the first and only state in the country to pass such a law, and already its benefit to the state and the public in general is to be seen in the fact that in a single day nearly $2,000 has been paid for leases. . . . The new law has already resulted in an enormous amount of prospecting and the discovery of several fine mines, which will pay annually great sums to the state. This is apparent when you remember that the Chandler, which occupied only two forties, has paid as high as $90,000 royalty a year. The new law ensures the exploration of every forty acres of state land in the two iron belts, and if there is any iron on any of them it will be discovered right away instead of lying unused for many decades."

> "The ore has been sold at a lower price than has ever before prevailed in the history of our Lake Superior mines, being about one-half the price received four years ago, while the cost of production has not correspondingly decreased, nor could the mining cost be reduced very greatly, although minerals have very much depreciated in value ; but labor, the chief element of expense in the production of ore, has lessened about twenty per cent., and the royalty paid by these companies which mine on a lease remains in most cases the same as heretofore. Altogether it has been a discouraging year in iron mining.
>
> "The matter of royalty, so-called, is one that needs further modification to adjust itself to the requisites of all parties concerned. Very many of the mining companies do not own the fee of the land in which the ore is mined ; they simply hold under a lease for a given period, which provides for the payment of a certain sum to the owner of the land by the company for each ton of ore that is mined. This payment is termed a royalty, and has usually heretofore been fixed at fifty cents per ton ; in some instances it has been seventy-five cents. Now, however, in the new leases that are made it is usually twenty-five or thirty-five cents per ton.
>
> "Fifty cents per ton royalty is too much ; more than in most cases can be paid and leave any margin for the company. When soft ore sells as it does now at $1.60 to $2.50 per ton at the mine, the lessor has the best of it ; he has none of the trouble, none of the risk, and is generally sure of his pay. These leases require that a certain minimum amount of ore shall be mined annually, that is, that the company holding the lease shall pay at least a certain sum annually whether any ore is mined or not. Of course this is a burden which some idle mines have to bear, and which they do assume in preference to taking the risk of mining ore in the present state of the market. When the mining cost and the royalty exceed the selling price of the ore the result must be suspension of work in whole or in part of the mine until a better state of things exists."

NEW YORK AND SOUTH CAROLINA.

The mining law of New York is antiquated and somewhat complicated, but it appears to err in reserving to the people of the state a right of sovereignty in mines which the state has not got—such as mines of gold and silver, and mines of all other metals discovered on the property of aliens (who by law are not allowed to own land property).

The state however has been for a long time in receipt of a revenue from a duty or royalty imposed on salt manufactured on the Onondaga salt springs reservation, a tract of land about ten miles square, including the city of Syracuse, one or two neighboring towns and Onondaga lake, which was ceded to the state by the Indians in 1795 in consideration of a cash payment of $1,000 and annual royalties of $700 and 150 bushels of salt. The reserve was divided into ten-acre lots and leased upon a royalty which ranged from three to twelve and-a-half cents per bushel down to 1846, when it was reduced to one cent.

The maximum rate was at first levied to aid in the payment of the Erie canal, and a total sum of $2,055,458 has been contributed from this source for the construction of canals in the state.

The total net revenue derived from the manufacture of salt in the sixty-eight years 1818-86 was $4,296,664.

In South Carolina a royalty is collected upon phosphate rock taken from the beds of navigable streams, from salt marshes between high and low water marks, and some additional swamps, lands and streams which have been claimed by the state. Phosphate is also found on higher ground which long ago passed into the hands of settlers, and it is therefore free from the payment of royalty to the state.

From 1872 to 1881, both years inclusive, the aggregate of royalty paid into the state treasury was $717,546, while the total revenue from all sources was $11,562,409. In the ten years 1882-91 the revenue from royalty was $1,820,350, and from all sources $9,843,286. In the first ten years of the period the phosphate royalty was six per cent. of the total revenue, and in the second ten years it increased to twelve per cent. But that it is steadily and rapidly increasing is shown by the fact that for the five years 1887-91 the royalty constituted eighteen three-quarters per cent. of the whole revenue. Had the output of last year not been arrested by a dispute between the government and the largest mining company, this percentage would have been considerably higher.

The royalty on river rock is one dollar per ton, which is about one-seventh of its market value, but in his message to the Legislature last year the Governor of the state recommended that the rate be increased to two dollars per ton. Referring to the Coosaw Mining Company, with which the dispute has occurred, the Governor said:

> "The Coosaw river, to which this company lays claim, is perhaps the best phosphate field in the world, and the lease under which it has been mined for twenty-one years has made every stockholder wealthy. Their plant, which has been obtained from the surplus profits, is valued at $750,000 or over; and in the meantime by fabulous dividends the original capital of $275,000 has been returned to the stockholders, as I am informed, over and over again. When you are told that the output of this company this year has been 107,000 tons, worth $7 per ton f.o.b., and that the cost of mining this rock, including royalty, cannot exceed $4.25 per ton, and is believed by many to be much less, you will see that the margin of profit exceeds one hundred per cent. on the original investment."

It would therefore appear that the Governor was not far mistaken when he expressed the opinion that it is possible to double the income from the phosphate royalty, "without injuring the industry or interfering unduly with any vested right." His estimate of cost of production is fully substantiated by Dr. Francis Wyatt in his book on the Phosphates of America.

GREAT BRITAIN AND IRELAND.

The question of mining royalties is now receiving careful attention in Great Britain and Ireland. A Royal Commission appointed in August, 1889, has made three reports to Parliament, covering 1,000 pages of evidence and other information, and its work is not yet finished. The special object of this Commission is—

> "To inquire into the amounts paid as royalties, dead-rents and way-leaves on coal, ironstone, iron ore, shale, and the metals of mines subject to the Metalliferous Mines Act, 1872, worked in the United Kingdom, and the terms and conditions under which those payments are made, and into the economic operation thereof upon the mining industries of the country; and, further, to inquire into the terms and conditions under which mining enterprise is conducted in India, the colonies and foreign countries by the system of concession or otherwise, and the economical operation thereof."

The notes of evidence of witnesses examined by the Commission, the summaries of replies to questions addressed to mining proprietors and associations and various appendix papers in the reports already printed merit careful study by those interested in this subject in all its diverse relations.

If in Great Britain, where mining has been carried on for centuries, the royalties levied upon ores and minerals are deemed to be worthy of an exhaustive enquiry by a Royal Commission of twenty-one members, it ought not to be a cause of surprise if the question is not well understood in a country like ours, where the mining industry has hardly yet been established.

For this reason I have deemed it advisable to make such extracts from the reports of the British Commission as appear to me to present the subject from the various points of view in which it may be regarded by miners and mine owners, moneyed men and laborers, lawyers and law-makers—in short by representatives of every class directly or indirectly concerned in the prosperity and stability of the industry.

EXTRACTS FROM THE BRITISH COMMISSION ON MINING ROYALTIES.

Alfred de Bock Porter, secretary and financial adviser to the Ecclesiastical Commissioners:

1. What position do you hold? I am secretary and financial adviser to the Ecclesiastical Commissioners.
2. And have they a large property in mines and minerals? They are, I suppose, the largest owners of minerals in England.
3. What kind of minerals do they possess? Coal, ironstone and lead; but coal is the principal mineral.
4. Besides being owners in their own right, have they any other control over minerals? No minerals belonging to the incumbent of a benefice can be worked without the intervention of the Commissioners. The lease is granted by the Commissioners with the consent

of the patron and of the incumbent, and the reservation of the royalties is made to the Commissioners.

5. Can you state what income is derived by the Ecclesiastical Commissioners from royalties, way-leaves and other profits? Roughly £300,000 a year annually.

19. Is there any certain or fixed rent reserved in your leases? Usually there is a certain rent determined either by the number of acres in the royalty or by the probable output of the mines. There is a tentale reservation which is liquidated by the certain rent.

20. Do your fixed rents depend generally upon acreage or upon other conditions? Usually upon acreage. There are, perhaps, some exceptions, where we have been able to ascertain the output for some years past, that has been an element in determining the certain rent.

21. Can you give us the maximum or minimum of your fixed rent per acre? What is the fixed rent? We have here an acreage of 1,200 acres and a certain rent of £1,500; and another case of 400 acres, and a certain rent of £500 a year.

22. But then the answer we received from the North of England Coal Trade Association is a certain rent of £1 to 30s. a year? That is about correct.

24. And then we come to the royalty on the tonnage? Our reservations are wholly by tonnage rents; they are reserved at so much per ten—which is 48 to 50 tons—but the modern leases have the tentale fixed at so much per ton, the average royalty ranges between 4d. and 5d. per ton.

25. Can you tell us what is the maximum or the minimum? Everything depends upon the situation of the colliery and its access to railways or staiths for shipping coal; it ranges, say, between 7d. and 2½d.

26. Do you ever make an arrangement to vary the tonnage rate by a sliding scale in accordance with the selling price of the coal? During the depression of the last few years, wherever a lessee has come for an abatement of rent, we have said that we can only grant an abatement on the condition that he accepts a sliding scale. The Commissioners were quite willing to meet their lessees in times of depression, on the understanding that, if they abated the royalty, then there must be a corresponding increase in the event of prices rising, and the larger lessees accepted the sliding scale.

99. You have not stated anything about the royalty charged in lead mines? We have put those on a sliding scale. When lead is £20 per ton we have a fixed fraction; and between £20 and £17; £17 and £14; for every £3 we reduce it until it gets below £10, and the extreme range is about one-tenth to one-eighteenth.

100. Then how long are those lead leases granted for? 60 years. There is a large amount of capital involved in them.

Robert Ormston Lamb, chairman of the Northumberland Coal Owners' Association:

138. When you speak of an average rent at 5d., I suppose you mean royalty? Yes. In the other colliery in which I am interested our lowest rents were 5d. per ton for round and 2d. per ton for small coal, and the highest 8¾d. per ton for round and 4d. per ton for small coal, while the average on round and small together was about 4½d. per ton. For a number of years previous to 1888 the Northumberland coal trade was in an extremely depressed condition. In that year, compelled by the depression, we made application to all our lessors to have our rents either permanently reduced or put upon a sliding scale, varying with the price of rent of coals free on board, and, in many cases, these applications were acceded to. For the first year after these scales came into operation the price of coal ranged very low, and in that year the result of the sliding scale was that our average rent became about 3½d. per ton. Since that time, and rising with the price of coal, the rent has increased to 6d. per ton. The rate of graduation in these scales is on an average of about one-fourteenth of each advance in price from the standard price and basis rent. All these rents are paid clear of all taxes or deductions except the landlord's income tax. We pay all local rates, and these, on our total output, amount to about 1¼d. per ton. So far as my knowledge and information go with respect to the rest of the collieries in Northumberland, the sliding scale is not universal, but there are several instances during the last three years in which it has been granted. In my opinion the system of fixing rent by a sliding scale, varying with the price of coal, is fairer to the lessee than the system of a uniform fixed rent per ton, and is also fairer to the lessor. The advantage seems to me to be, that when prices are low the sliding scale is lower than a uniform rent, while it is higher when prices are higher. When prices are low and the profits are small, if any, a difference in rent is more felt by the lessee, while, when prices are better the advance in rent which the lessee pays the lessor is less appreciably felt.

251. Would you be in favor of a sliding scale without a minimum rent? I do not think it really matters, because if you go down to a certain price, say in Northumberland, where the minimum figure quoted is 7s. 6d., practically, if you are getting below that price, the coal-field there would cease to be worked, because you could not possibly live, you would become bankrupt. It is the very lowest price you could live at. If you get, for instance, 6s., unless an entire change of cost comes over the scene, you would absolutely not work the pit at all.

304. Would you say that there is a general aversion on the part of landlords to give a sliding scale? No, I think in Northumberland and Durham many of the leading viewers favor the principle of a sliding scale, and in consequence of that being so my belief is that the lessors will grant sliding scale leases. Their advisers, as a rule, are strongly in favor of the principle of a sliding scale.

308. I am not sure that the Commission understand exactly what is meant by a sliding scale. It means, does it not, a certain proportion of the selling price? It means paying the rent to the landlord on the realised ascertained price obtained by the lessee.

Lawrence William Adamson, chairman of the Hollywell Coal Company and director of the East Hollywell and Ryhope Coal Company, East Hollywell:

436. Have you any information to give us about the principle of the sliding scale? Yes; I may say that, generally, I entirely concur with Mr. Lamb's views as to the very material advantage which the sliding scale confers on lessors, lessees and miners. As to the lessees, for whom, of course, I am most interested, it enables them to do this: it enables them in time of depression to work more regularly, thus it confers a material advantage upon the miner by ensuring more regular employment. With regard to the lessor, although apparently it may in time of depression decrease the revenue derived from his royalty, I think the swing of the pendulum when times improve brings it practically to something like a fair average. He also enjoys the advantage of having his coal more equably and regularly worked. I think, therefore, on the whole it confers a most decided advantage on all three.

440. I believe that there is something else that you wish to say with regard to the general principle? With regard to the general principle of the sliding scale, as I have said, the great point I imagine is this, that during bad times it enables you practically to continue working when you could not do so otherwise; it lightens the burden at the time of depression, and in the time of comparatively good trade it is not severely felt, and in time of really good trade the royalty rent can be paid though it may be even double what it is in the depressed time. The mean point between the two times of depression and flood practically gives the lessor over a series of years the same advantage that he would have had had he had an uniform rent during the whole period, but the relief is most material to the lessee.

612. You referred to some cases where, under certain circumstances, mines were worked at a great loss, for some years perhaps, by the lessees? I referred to two cases in which, ever since I got into them, they have been working at a loss until just this last year or so.

613. I would ask whether in those cases the lord or proprietor continued to receive his royalties? The lord or proprietor in every instance that I detailed? No. Once he became convinced that our representations were correct, he made most important abatements. Had he not done so the pits would have been closed. In one instance we gave notice to close the pit of one small subsidiary royalty owner in Northumberland who refused to comply with our terms, whose coal was exhausted, and wanted unreasonable terms for an underground wayleave. We did without it, but then it might have been that we could not have done without it, and then we should have had to pay the demand. Personally, I think the landlords do not behave badly. I ought to say that in one colliery that I mentioned, in which very heavy losses were incurred, the landlord in one year gave up the entire rent—every farthing of it.

614. But he could have enforced it if he had chosen to do so? Yes; but then we should have given notice, and given up his pit, though we would have lost the whole of our capital.

615. On the termination of the leases, the lessees I understand have no right of renewal? No absolute right.

616. Do you think it would be desirable that they should have a right of renewal on reasonable terms? I should think so, decidedly, as a rule. The longer the term and the greater the privilege conferred on the lessee, unquestionably the more beneficial it is to him.

William H. Hedley, chief viewer of the Consett collieries belonging to the Consett Iron Company:

734. What is your view of the economical effect of a fixed royalty, as compared with that of a sliding scale royalty? A fixed royalty might be expected to operate in restraint of a free and continuous working when prices became so depressed that continued working would involve a loss to the lessee. The cases are probably not numerous, however, in which with a royalty fixed at a fairly moderate figure this effect would be experienced. Of course, generally speaking, if the royalty were much above the average then a stoppage in bad times would be likely to take place, but these are just the sort of instances that many lessors have shown a willingness to meet by temporary reductions of rent.

745. Are you of opinion that the law which governs royalties is the same as the law which governs the rent of land? I think the principle that governs the letting value of coal is very much the same as that which governs the letting value of the land; it is a ques-

tion of supply and demand, I suppose. The lessor seeks to get the highest rent he can, and the lessee seeks to arrange for the lowest rent he can on his side, in the same way that a tenant wishing to take a lease of a farm would seek to get it on the best terms.

746. Are you of opinion that the amount of the royalty enters into the price of the coal or not? Of course to the extent of it it does enter into the price of coal, and if it were entirely done away with coal could be sold so much cheaper.

747. In that respect then you would think the principle would differ from the principle of the rent of land, because it is supposed to be a sound doctrine of political economy that the rent of land does not enter into the price of agricultural produce? I do not see how that can be argued. We have argued, for instance, that if the easement charges were entirely done away with that would affect the price; and the same would hold as to royalty rents; if they were entirely done away with I suppose it would affect the price to the consumer.

Sir Isaac Lowthian Bell, president of the Cleveland Mine Owners' Association:

1040. This Commission is not instructed, and has no desire to enter into all those general questions which you dealt with in your paper and in your evidence before the Royal Commission on Depression of Trade and Industry; but we should desire very much to have your opinion in respect of that part of your paper and of your evidence which touches the question referred to us, namely, the question of royalties. I think you dealt with it in the 74th paragraph of your paper at some length, and in your evidence? Yes, that is so.*

1041. Perhaps you would give us shortly what your opinion upon that part of the subject was and is? I would say, generally, that what I mentioned in the evidence your lordship has spoken of has been confirmed since that time by daily experience. I do not know whether it is the wish of the Commission that I should say anything about the nature of the royalty itself, in respect of which a good deal of difference of opinion prevails; although, practically, I do not think it is of much importance in the present inquiry. It may be quite true, for example, that a royalty will only be payable when the demand for minerals exceeds the supply which can be procured at the cheapest cost, and therefore the royalty will be the difference in cost between that of production and the placing of the product in the common market of the most favorably situated mine. Well, that is a condition of things which really very rarely obtains. It would be impossible to lay your hand on any district that I am acquainted with in which the conditions exactly responded to the law which has just been laid down. If the Commission would fancy the position

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*Extract from statement put in by Sir Lowthian Bell relative to his evidence before the Royal Commission on Depression of Trade and Industry, and referred to above:

Royalties.—These not only differ in different districts, but they vary in mines situated in the same locality. These irregularities may have arisen from the leases having been granted when trade was prosperous or the reverse; or from the mining difficulties being greater in the one case than in another; or from differences in the quality of the mineral; and lastly, from the geographical position of the field containing it.

It is not intended to deal with any extremes, but to take an average of what is usually paid in different districts.

In the United Kingdom the property of the minerals is, unless other arrangements have been entered into, vested in the owner of the soil; in any case the person so working them has to pay for the right of so doing.

To prevent the mine owner leasing large areas of ground and leaving it unworked, fixed rents are charged whether any mineral is worked or not; such fixed rents being regarded as payments on account for future workings. The lease sometimes permits the lessee to set such payments against the mineral taken away during any period over which it runs. At other times this privilege lapses at fixed dates as may be agreed to by those concerned. The amount involved in these fixed rents is sometimes very unconvenient to the lessee. The ironmaster may have to contend with adverse times when the state of trade would suggest either a reduction of make or its entire discontinuance. He has, however, not only to face this fixed payment, but he has to keep his mines free from water and the machinery, etc., in good repair. I could name cases where £20,000 or £30,000 a year would barely suffice to meet the expenditure under these two heads.

The royalty dues paid in Cleveland for ironstone are about 6d. per ton. In Lincolnshire and Northamptonshire they are sometimes double this sum because, instead of expensive shafts and machinery being required, the mineral lies near the surface with a covering of greater or less thickness of sand or rock. In such cases it is got by simple quarrying. Coal varies in different places, but 6d. to 1s. per ton may be regarded as common rates. A common rent for limestone is 1d. to 3d. per ton. In addition to these charges the lessee has to pay double rent for all surface damage and to restore the soil at the end of his lease or pay its value.

In Germany the ownership of coal and iron ore is vested in the state. The royalty paid on the former is 2 per cent. on the profits. I suppose that at a selling price of 6s. per ton the profit will be such that 1½d. per ton will cover this payment. For iron ore nothing is paid for the right of working. No objection on the part of the owner of the soil is allowed to prevent the minerals on his property being worked, such prohibition being considered as inconsistent with the interests of the nation.

In the United States the ownership of the minerals goes with that of the surface, and as coal and iron ore lands have been and still are sold for a few pounds or even shillings per acre, the royalties on the minerals like the agricultural value of the surface cannot be compared with what is paid for similar proof a navigable river, for example, which separated a large coal district on one side from an iron ore district on the other, probably the works would be placed on the river itself, but it is quite clear that there would be no parity between or among works there placed if every portion of that district were taken up successively by different people at greater distances than the river. You would have, of course, the district next to the river in the most favored position, and every time a fresh adventurer made his appearance he would have to content himself, of course, with an inferior position. The minerals might be equally good all over the district; but still it would be absurd to pretend for one moment that they were all equally well situated. Now that is a condition of things which in my opinion would always produce a system of royalty; that is, there would be a preference shown for works the most favorably situated in this imaginary mineral field; and in the event of the owner wishing to sell a work of that kind, he undoubtedly would command and be able to obtain a very much higher price than would another owner situated, say, 10 miles from the river. It might not be a question of sale, but one of rental, and there you have at once the system of royalty springing up, because instead of a capital sum his advantageous position would be represented by a rent, in other words, by a royalty. I do not say the change would grow up the next day, but it would very speedily grow up, and in point of fact that would occur which, as I have shown in the book your lordship has mentioned, has occurred in countries where the minerals, being the property of the state, were handed over, practically without any payment, to adventurers who began to work them. The government in those countries acts in the interests of the commonwealth; it expects, and by offering facilities for capitalists to settle within their territory, they are promoting the prosperity of the district or the country at large. But no sooner does a private individual obtain a concession such as that described than he does one of two things. He either works it himself and looks to obtain all the profit for himself, or else, as is very frequently the case, he sells it and reaps his profit at once. Now on Lake Superior, which is one of the richest iron ore producing fields in the world, not only in extent but also in the quality of the ore it produces, that has been the universal practice. An individual received a concession when the country adjacent to Lake Superior was, as a great deal of it still is, primeval forest; but of course this rich deposit attracted speculators, and these mines were in many cases subsequently sold at very high prices. The same prevails here in Europe. In Spain, for example, you have Bilbao, a recently developed dis-

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perty in older countries. Further on it will be explained that notwithstanding this state of things royalties are often as high in North America as they are in any part of Europe.

In France all ironstone, save a trifling amount which is of an illuvial character, and all coal since 1810 have been claimed by the state. Concessions to applicants are granted on an annual payment of about 8s. per square kilometre (about 243 acres). In addition a tax is levied not exceeding 5 per cent. on the profits. If the latter amounted to 2s. per ton the royalty would be below 1¼ per ton.

In Belgium before 1830 the iron ore was the property of the state, when it was transferred to the owners of the soil by whom leases are granted on payment of from 4¾d. to 2s. per ton. Inasmuch, however, as very little ore is now worked in Belgium the question of royalty is unimportant. Coal remains the property of the state. The rent on it is 1d. per annum per hectare (a little above two acres) with 2½ per cent. on the annual profits. This on an assumed profit of 2s. would be under ¾d. per ton.

The minerals in Spain also belong to the state, concessions being granted on nominal terms.

From the data already enumerated in reference to the royalties it may be assumed that the charges are as follows:

In Great Britain—Pig iron per ton, Cleveland, 3s.; Cumberland and Lancashire, 6s. 3d.; Scotland, 3s., using clay ironstone, and from 5s. to 6s., using black band ironstone—the average being 4s. 10d. On iron ship plate 5s. 9d. will represent a common charge for royalty; and 3s. 8d. to 7s. 3d. on steel rails according to the ore from which they are made.

Germany—6d. on pig iron; 1s. on iron ship plates; 8½d. on steel rails.

United States—The royalties vary from nothing to 6s or 7s. per ton for reasons to be given hereafter.

France—On pig iron, 8d.; on iron ship plates, 1s. 1½d.; on steel rails, 11d.

In the present depressed state of the iron trade in this country, while ironmasters and mine-owners are working at a rate which practically gives no profit to the capital employed and in many cases results in a loss, it is widely felt by workmen as a grievance that the landowners to whom royalties are payable receive the full amount reserved by the leases.

It is contended by some that should the present low prices continue those engaged in mining in this country must be reduced to bankruptcy, and a great industry must be extinguished unless the receivers of royalties are willing to abate something of their legal rights, which now give them about 3s. on every ton of the cheapest kinds of pig iron made, or very nearly 10 per cent. on the gross price of the manufactured article.

Royalties on minerals resemble in their relation to the cost of production and the price paid by the consumer, the rent paid by agricultural land. That is to say, a royalty will only be payable when the demand for minerals exceeds the supply which can be procured in the easiest and cheapest manner, and the theoretic royalty will be the difference in cost between the cost of production and placing in the common market of the more favorrably situated mine and that which is the most expensive to work and which yet can be worked at a profit. But in practice most leases of mines are in the enjoyment of a beneficial lease, not a rack rent, for mining leases are necessarily usually for a longer period than agricultural tenancies owing to the need of the lessee for security of tenure on account of the large amount of fixed capital required in opening up a new mine. Thus as a new mining district is opened up the more remote or poorer deposits in a growing trade will be leased possibly at as high a royalty as the richer or more accessible mines which were leased when the prospects of the districts were less assured. But even now the trict, where the same system has prevailed; in Germany, in Russia—in point of fact wherever minerals can be cheaply obtained. I may mention that within the last month or two a small patch of land near a foreign port, I believe, not exceeding 20 acres in extent, and containing iron ore of very good quality, but no better than a great deal of the same mineral found elsewhere in the same district, has changed hands, and I understand there has been paid for it nearly a million sterling.

1042. Then I take it that the gist of what you have told us is this, that under any system, whether a system of law under which the proprietorship of the minerals rests with the proprietor of the surface or under which the minerals belong to the state, the effect would practically be the same, because if the state makes a concession of these minerals to any individual that individual practically stands in the same position as the proprietor of the land in this country, and will get the most he can for the advantage which he receives from the concession? That is certainly my opinion. Human nature will have to change very much indeed before anything but that result can happen, I think.

1043. I think the other opinion that you gave was this: that, as the value of different properties that the man would possess depends upon natural circumstances, it can by no law be equalized? Impossible.

1044. Those natural circumstances being the more or less productiveness of the matter below the soil, or the more or less nearness to the market? Certainly; these are the two circumstances which regulate the value. There is, of course, a third; that is, the facility with which the mineral itself may be extracted. But if it is equally cheaply worked all over the district, and if it is of equal richness, then of course the geographical position is the only thing to consider. But that identity very rarely happens, and a complete equalization of position becomes a very complex question. In Cleveland, for example, the iron ore there gradually diminishes in productiveness as we travel from the banks of the Tees, and at the same time that it does that the railway charges for conveying an inferior material from the more southern parts of the district increase.

1045. Am I to understand then that your conclusion would be, although in your paper and in your evidence you showed this anomaly, that the royalty paid upon pig iron, for example, in England is 3s. per ton, and in Germany 6d. per ton, and in Spain nothing, we may say that, practically, in respect of those mines that are being worked there would be no substantial difference in the actual amount paid by the people who are working the mines? I do not say that there are not cases where the contrary prevails. Supposing the original holder of the district were working it himself, then he would have an advantage over any-

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owners in the less favourably situated mines are forced in a losing trade to make concessions to their lessees, though they are able if they hold out for their full legal rights to see all the capital of the tenant made valueless before the loss begins to fall on themselves in respect of the royalty.

The subject in question has been receiving some attention of late in the press, and the injustice as it has been termed has been remarked on of the workmen having their wages reduced and the railway companies their rates lowered, while the landowners remain unaffected during the long-continued depression in the iron trade. The remedy recommended in some instances has been a drastic one, viz., confiscation of the landowners' rights. I have not in my experience met a single lessee who dissociates the right of his landlord to the minerals any more than he would question his title to the surface. As is known, when the profits were very high the landlords had to be content with the same rents they received under a very different state of things. It has, however, to be remarked that the present royalties were arrived at by previous experience of the value of the produce of the mines, and there is no doubt that had the present prices of iron been contemplated as possible when the leases were entered into some provision would have been made for such a contingency. It would seem therefore open to consideration whether by means of a sliding scale the payments to the landlord should not be made dependent on the market value of the mineral, a system which in some cases has already been adopted.

With regard to confiscation itself, the only ground upon which it could be recommended would be, not for the advantage of the lessee but for the good of the commonwealth. But in many, indeed I suspect in the majority of cases, both would prove illusory. Let us take the case of the Bilbao mines. The value of their produce was practically settled by the nature of the competition which they would have to encounter from the hematite mines in existence at the time the concession was granted. The Spanish government handed over its rights to certain individuals without any reference to the value of the ore or having any other object in view than those of attracting capital to the place and of providing employment for its subjects. They who had been judicious and fortunate enough to be the first to embark in mining adventures there looked upon the affair from an entirely different point of view. A large tract of mineral property was transferred by the original holders of the concessions to new parties at a high price, who, under the conditions of the transfer, have no other alternative but to charge a royalty which never reaches the national exchequer of Spain. I met with many similar instances in the United States. The mines on Lake Superior are rich in them. Skilled geologists with energetic minds pushed on into this then unknown region, indeed so little known at the present day that I found the native Indians still living in its vast tracts of unclaimed land. One enterprising speculator purchased from the state a property of 40 acres for a few thousand dollars. By him it was let to a second who agreed to pay a royalty of 2s. per ton on the ore to the original purchaser; and the new owner, after an expenditure of £3,000 to £4,000, passed the property on to a third, who paid for the privilege of working the ore in addition to the royalty of 2s. per ton the sum of £75,000, leaving thus a profit to the second holder of £71,000 or thereabouts. Again, in Pennsylvania there is the Cornwall mine, for which I was informed that the owners refused from the Philadelphia and Reading Railway Company a million sterling. I do not vouch for the accuracy of the sum, but I believe a very large amount was actually offered.

one who had to pay a royalty; but in order to gain for his works a position as a commercial undertaking he might have to sacrifice a part of that advantage, but he could afford to undersell a man who was paying a royalty to an original holder who had acquired a concession for a nominal sum.

1062. Then, speaking of how royalties are charged in Spain, I think you said that somebody gets a grant from the government, and by-and-by does not work it himself, but lets it to somebody else? He may or may not; he may have worked it himself, and in some cases has done so.

1063. Do you think that makes a condition of things on the continent, so far as Spain is concerned, exactly similar to the condition of things prevailing here? Practically it is so.

1070. Do not you think these leases in Spain could be regulated in such a way as to make the terms equitable for lessees, while permitting a considerable sum to go into the national funds in the form of taxes? I think if I were at the head of the Spanish government and I saw foreigners coming in and reaping very large sums of money from mining enterprises there, I should begin to inquire whether a reasonable portion of it should not go into the national exchequer.

1071. Do you think it would regulate the conditions and make them equal all round by imposing a higher tax on a mine situated nearer that river to which you have referred than on another mine more distant? I think that would be perhaps interfering with a principle of political economy which I am not prepared to admit, because you want to level the bad mines up to the position of the good, or to level the good mines down to the position of the bad. I think you cannot do that.

1080. I understand you to say that the royalties were very much regulated by the amount that lessees were inclined to offer? They are regulated no doubt when there is competition for them, then they will rise like any other commodity. I know of minerals in good times being undoubtedly taken at a much higher rent than the same minerals would have commanded in very bad times.

1081. Exactly; they are regulated by supply and demand, just as other commodities? Yes, more or less they are.

1101. Now, some reference has been made to the sliding scale system; should I be correct in saying that the sliding scale would, as a rule, adjust the actual rent paid more closely to the rent that the mine could bear than a fixed royalty? I do not suppose that we should get our ironstone any cheaper than we are getting it now; that is, it would be, I suppose, unjust to ask a mine owner to reduce his price below the present standard without at the same time agreeing to increase it in the event of iron being higher; so that I think you would find probably there would ultimately be an adjustment. At the same time it is difficult, and so far as I am concerned impossible to predict what effect the future would have in case of royalties being abrogated. If you take some of the diagramatical charts of prices, you will find that there has been a constant wave up and down over the last fifty or sixty years in the price of iron. But if you draw a line from the top of one elevation to the top of an elevation which took place fifty years after that you will find that there has been a gradual descent in the extent of the highest prices. The waves continue, but the amount of travel that they have is very much decreased, and this has taken place without any alteration in royalty dues.

1102. Has any difficulty been found in Cleveland in depressed times owing to the royalties being fixed in amount? Of course, everything that goes to increase the cost has its effect in increasing cost.

1103. I rather mean has it led to the closing of mines or to the reduction of wages? No; the price of iron has led to that, but it would be very difficult to say that it was the royalty which had put 1s. 6d. per ton on a material which cost you more than twenty times that. Of course it played its part. The 1s. 6d. is for ironstone royalty. I am taking it at 6d. per ton, and it takes about 3¼ tons to make a ton of pig iron.

1109. If the minerals of a country could, on an average under the world's competition, be worked just to a sufficient profit to ensure working if no royalty rent were charged, what would be the effect if these minerals belonged to the state as compared to their belonging to private persons? Well, I do not know that it would be very different. There are certain minerals belonging now to branches of the state, and I cannot say that I find the state is a much better landlord than anybody else.

1112. But it would not, of course, be worth the while of any private owners of minerals to let them be worked for nothing? Certainly not. And that is what I venture to say was in the mind of the Spanish and other governments where they look for their remuneration in the increase of prosperity to the country. They look upon it as a national question.

1117. If the minerals of a country could, on the average under the world's competition, be worked just to a sufficient profit to ensure working if no royalty rent were charged, what would be the effect if those minerals belonged to the state as compared to their belonging to private persons? I cannot see that there would be any difference.

1118. I am asking you what would be the effect under those two conditions? In the one case paying no rent, and in the other case paying rent?

1119. In the one case belonging to the state, and in the other case not belonging to the state? Well, I think if I were the landowner under the circumstances and I was going to get no rent for my minerals, I would let them lie there until the time came when I I could get it.

1120. And if you were the nation what would you do? If I were the nation I should be in an entirely different position, because the nation's interests are very much wider than those of individuals.

1121. Do you think the state would give the permission to work the minerals in the interests of the community? Yes, in the interests of the community.

1122. Even without exacting a royalty? Yes; I think it would do so, because in Prussia, for instance, the state has an undoubted right to the iron ore of Prussia, but it allows it to be worked in the way we have been speaking of, namely, by concession, for which nothing is paid.

1125. Take two states beside each other, in one of which private ownership prevails, and in the other the minerals belong to the state, and the two compete with each other? Very well, then I think either the community or the individual who is working the minerals would profit to the extent of the royalty.

1126 You think the private owner, if his interests were not to be served, would not permit the coal in his fields to be developed, but you think the state, in the interests of the community, would encourage the development, even although there were no immediate profit? I think the state might do so.

1127. I will put another question, because I think it will reconcile the two views. If the industry in a country where the minerals belong to the state will bear a royalty rent at all in the world's competition, the highest royalty rent that the minerals will bear will in all probability be paid by the ultimate worker, no matter what the terms are on which the state concession is given? Yes, I think so.

1128. That is to say that if the commodity will bear a royalty rent at all and the state grants those minerals free of rent, what ultimately happens is that in the transmission of that royalty from year to year it ultimately bears to the actual worker whatever royalty rent it is capable of bearing in the world's competition? Certainly.

1129. That is not irreconcileable, of course, with the other hypothetical position? Of course the position upon which you are basing the problem is an extremely difficult one. To day it might not bear any royalty at all. For example, the ordinary royalty of the Blackband ironstone in Scotland before 1824 or 1828 perhaps was about 6d. per ton. The hot blast was discovered and it enabled them to treat the Blackband with great ease and readiness, and the consequence was that an estate belonging, I think, to Sir William Alexander, was let at a fixed rent of £12,000 a year and 7s. 6d. per ton royalty. In 1862, for minerals on the west coast of England, the hematite iron ore of Lancashire or Cumberland, I forget in which county it was, which was usually let at about 2s. per ton was let at 7s. 6d. per ton; and all this would affect very greatly the position of affairs when they came to be discussed in the future under an entirely different state of things.

Marshall Nicholson, of the West Yorkshire Coal Owners' Association:

1287. Have you at all thought of the usefulness of a sliding scale as compared with a fixed system? Yes, I have considered that. I consider that it is of very little moment, because if you were under a contract and you had a sliding scale you would feel the benefit in depressed times, but of course whatever benefit you got then you would have to pay back in better times. Therefore on the whole I do not see much advantage in it.

John Devonshire Ellis, chairman of the South Yorkshire Coal Owners' Association:

1484. Now, so far as South Yorkshire is concerned, as far as you know, is there any reason to complain of the actual royalty charged for coal let? No, it is a matter of bargain of course, and the bargain is almost always very honorably carried out on both sides. I do not think it is a matter of any complaint whatever.

1485. Then, as far as you know, and speaking for colliery lessees, is there any desire in that respect to interfere with the present system or to disturb it? I think, as a rule, they would be very sorry indeed to get into any other hands.

1486. Do you mean by that the state, for instance? Certainly, I think that would be a great objection. Most of the coal fields in our district are in the hands of large landed proprietors, such as the Duke of Norfolk, Earl Fitzwilliam, the Earl of Effingham, and Mr. Foljambe; they are all of them most liberal, honorable landlords, and I scarcely ever hear the slightest complaint made by anyone. The difficulty always arises, I think, when the property is in the hands of either trustees or of small holders. That is my experience on this matter.

1493. Can you tell us what is the quantity of coal produced in Yorkshire last year? It would be about 23,000,000 tons in 1889 for the whole of Yorkshire About 13,000,000 were produced in South Yorkshire and about 10,000,000 in West Yorkshire.

1494. I think you said the average royalty was 6d. per ton? Yes.

1495. Is that upon the gross output, or after deducting anything for the free use of the colliery? It is taken on the gross output, I think.

1496. Do you think that that would give a fair approximation to the amount of royalties paid in South Yorkshire? I think it would. We pay about £20,000 per year.

Francis Abigail, member of the New South Wales Legislative Assembly and Minister of Mines in the years 1887-89:

1529. Will you be so kind as to tell us what the law in New South Wales is as regards the property in minerals; whether, for instance, the same law affects all minerals, or, if not, with what difference. I am referring to the law of property in minerals, and to the laws under which the mineral industry is generally conducted? Perhaps I can best do that by referring to the state of the law and dealing with the sections which refer to these questions. By the Crown Lands Act of 1884, section 7, in the case of all lands granted for settlement the minerals are reserved to the Crown, and persons taking up the land actually for settlement only take the surface, the Crown reserving all rights to give authority to mine under that land for the minerals. This 7th section sets it forth; it is not necessary, perhaps, to read it, but it is in very clear terms that "all grants of land issued under the authority of this Act shall contain a reservation of all minerals in such land, and shall contain such other reservations and exceptions as may by the Governor be deemed expedient in the public interest. Provided that wherever it shall be found that land alienated under this or any of the said repealed Acts contains any mineral, and such land has been alienated subject to the minerals being reserved to the Crown, the Governor may permit the owner of such land to remove such mineral upon payment of such royalty, and upon such conditions as may be prescribed."

1535. Is the Crown Lands Act of 1884 applicable to all your minerals? Yes, and always has been, because the provision I have read is simply a provision transplanted from the 1861 Act into the 1884 Act.

1536. Therefore, practically you have no such condition as that which exists in this country, in which the proprietor of the soil has the right to the minerals underneath it? No, except in very special cases.

1537. Are those cases of any importance commercially? Yes; the A. A. Company obtained, very many years ago, a grant of a million acres, and in that grant there was a reservation of minerals. After they had been in possession for some considerable time they applied to Parliament to cancel that reservation, and I am very sorry to say that Parliament allowed the cancellation to go. The A. A. Company now stand out as being possessed of large valuable mineral lands containing coal and other minerals without the reservation.

1546. Are there any other exceptions, or is that the only important exception? There are other exceptions. Those other exceptions have been obtained by the passing of what we call the Mineral Conditional Purchase Bill. There were a number of parties in New South Wales who saw that they could obtain advantages if they could pass a law to evade that reservation principle, and this Mineral Conditional Purchase Bill was passed, which enabled them to take up both surface and minerals upon payment of £2 per acre, which was double the rate for settlement under our Land Bill. Under the Land Bill you can take up the settlement of land for £1 per acre, but under the Mineral Conditional Purchase Bill they obtained the land at £2 per acre, with a condition that they would spend another £2 per acre on improvements. That was in force for a short time, when we found that it was being worked very prejudicially to what we consider the public interest, and we repealed that bill, but not before a number of people had obtained possession of the mineral lands.

1547. Will you now explain to us the general method of dealing with minerals under the Act to which you have referred? Section 45 of the Crown Lands Act deals with Crown lands within proclaimed gold fields. That section sets forth that "Any Crown land within a proclaimed gold field which, after the 25th day of May, 1880, has been sold conditionally or by auction, or in virtue of improvements or otherwise, as well as any such land alienated under this Act, shall be subject to the following condition, namely: any person specially authorised in the prescribed manner by the Minister shall be at liberty to dig and search for gold within such land, and should it be found to be auriferous the Governor may cancel wholly or in part the sale of such land, and upon the notification thereof in the *Gazette* the proprietor shall be entitled to compensation for the value of the land as if it were not auriferous, and of the improvements thereon as appraised by the local board, and such land shall thereupon become Crown land within the meaning of the 'Mining Act, 1874.'" That, of course, gives the government the power, if the settler finds that it is gold land, to resume it for mineral purposes, but the settler has the right to make the first application for mining rights upon that land when it is resumed by the Crown.

1548. Is there a similar provision in respect to other minerals? Yes; section 91 of this Act says, "The Governor shall, notwithstancing the provisions of the 'Mining Act of 1874,' impose a royalty of not less than 6d. per ton on coal raised from land which may be hereafter leased; and such royalty shall be in addition to or in substitution of any rent payable by such lessee under the said Act, but shall not affect or prejudice any other condition of the lease."

1549. Does that mean that the government raises a tax of 6d. per ton on all the coal raised? It simply means that they charge a royalty of 6d. per ton on the coal raised from Crown leased lands.

1558. On what terms are these leases given? A gold lease is from 1 to 25 acres, and the rent is £1 per acre per year; under a lease for minerals other than gold the rent is 5s. per acre per year.

1559. Is there any limitation of the area for the other minerals? Yes; you can take a lease for the other minerals up to 640 acres, but for a gold lease, as I say, you can only take an area of from 1 to 25 acres—that is for reefing gold, but for alluvial gold you have to take it in blocks of a very much smaller area.

1564. Am I to understand that the rent for minerals other than gold is a fixed rent? Yes, of 5s. per acre.

1565. And that it has no reference to the comparative value of the minerals beneath the surface? No; there is one fixed rent for those, and the Crown makes no difference. Their desire is not to make so much capital out of the land as to get their mineral wealth developed and their people employed.

1566. Returning to a question which you answered just now: in the case of coal did you mean to tell us that where an individual or a company has taken a certain quantity of acres for the purpose of working coal, the royalty of 6d. per ton is chargeable upon all coal raised by that company? Yes, it is so.

1567. So that, in point of fact, this 6d. per ton is in the nature of a government tax upon the produce of coal? We do not look upon it as a tax. We simply look upon it as a small equivalent to the Crown for great benefits granted to private people.

1569. Can you give us, generally, your view as to the economical result of this system to the colony in respect of the development of the mineral resources of the colony? There can be no question or doubt, so far as our experience goes, that mining development under Crown regulations is vastly more beneficial than if it were in private hands. That is our experience; in fact, the feeling is so strong that I framed a bill before I left to take power to mine on private property, which I hope to be able to pass if I arrive back.

1570. Is that private property the property to which you have referred before? Yes, that property where it has been obtained without the reservation. We find that people who have obtained valuable mineral lands without the reservation are not ready to develop them.

1572. When the lease is once given as you have described it, does that constitute a property in the minerals to the person who has got the lease, or is it only for a limited term of years? For 15 years, with the right of renewal for 15 years more, and where it is worked according to the conditions the Crown never comes down upon the leaseholders in any way whatever, but will extend the time to an unlimited period as a matter of fact.

1575. Do you find that the party who applies for and gets the lease is usually the party who works the mine or not? I think not. Of course a man may be prospecting and may find a valuable coal deposit without having the capital to work it, and he necessarily sells the advantages he obtains from the Crown to those with capital who will work it.

1577. Do you know any cases in which parties rent these rights from others on condition of paying to them a royalty? No; I think it generally leads to the formation of a company. A man obtains these rights, and then he places himself in communication with a number of gentlemen who form a company, giving him certain monetary conditions for the rights he has obtained.

1578. Paying him a lump sum, I presume? Just so.

1579. Would it be fair to say that the interest upon that lump sum would be a species of royalty paid to the person who obtains this right from the government? Of course the amount paid to him has to be estimated in making a calculation as to the cost of the coal taken out.

1582. Is the same course taken in the case of iron as in the case of coal? No. Iron comes under the other term, and there are no conditions of royalty charged upon it whatever.

1583. You charge nothing? No royalty whatever.

1584. Do you make any charge in the case of any other minerals, with the exception of gold? No. Coal is the only thing that carries the royalty.

1650. You appear to think that to have the minerals in the hands of the government is a better system than we have here? Undoubtedly; I have no hesitation in saying that our experience proves it beyond a doubt.

1651. But supposing you had had the other system in operation, would you see any reason to change it by giving compensation to the owners of the minerals? Any private rights that were invaded should be properly compensated for.

1652. Do you mean surface rights? I am speaking not only of surface but of mineral rights. Any rights of that kind which would be invaded by any public interest should be.

as I say, properly compensated for. We are not communistic in New South Wales, and we believe if we invade people's rights we should pay for them.

1658. Do you think it is a fair principle to put all coal under the same royalty? What I have already stated answers that. I have said that in a bill I framed I fixed the large coal at 6d. and the small coal at 3d.

1659. But do not you think that the minerals of the country would be more readily developed in the hands of a private owner who had the power to charge much less royalty than 6d.? Our experience does not warrant me in saying that; I think that we have had one or two cases where private owners have opened up their paddocks for gold mining, and they have charged as much per week to each man as the Crown would charge per year.

1660. Yet, in every case it seems that when the mineral turns out more valuable than the charge made by the government, some private party gets the benefit and not the country at large, is that so? The country at large gets it indirectly, but the private people do not furnish the same facilities for working the mineral lands as the Crown.

1707. In the proposed legislation, where you propose to take authority to mine under the property of individuals who have acquired the mining rights, I understood you to say that provision was to be made for ample compensation both for the mining rights and for the surface rights? Ample compensation, and we give them three modes of obtaining it. That is, when the land is taken they send in to the Minister their estimate of its value; if the Minister does not accept that, they go to arbitration; if that is not accepted by the parties, we give them the right to go into the law courts and sustain their position there.

Barnard Platts Broomhead, barrister, and interested as landowner and shareholder in several mining companies:

1889. Have you had much practice as a solicitor in relation to leases of coal in South Yorkshire, Nottinghamshire, Derbyshire and the district around Sheffield? I have for a great number of years. I have many clients who hold very large mining royalties and very important leases.

1890. Could you tell us about how much the average of royalties in your district is? In our district the royalty up to within recent years was let or paid for at an acreage rate, so much per acre, say, for the Barnsley coal, so much per acre for the Silkstone coal, so much per acre for the Parkgate coal, and so on. Within my time, and certainly when I began practice, I never came across a case of footage rent. But now, in the majority of the cases, a rent of so much per foot per acre is paid, and not an acreage rent pure and simple. For instance, supposing you have got a four-foot seam to deal with, or what is supposed to be a four-foot seam, when you get to it the colliery lessee now instead of saying, I will give you £150 per acre or £120 per acre, as the case may be, would say, I will give you £30 per foot thick per acre, and then, as I find the coal free from dirt, I pay according to that footage rent. The ordinary rate in our district now is from £25 to £30 per foot thick per acre, and reckoning the yield of coal (I am not a mining engineer and I speak under correction) at something like £1,200 per foot per acre (I think that is about right), assuming that to be so, and I understand it to be so, then £30 would give a royalty of 6d. per ton, and £25, 5d. per ton, and so on. In my experience that is the average royalty.

1895. You, I believe, can explain to us the laws in force in the province of Biscay, in Spain, with regard to the working of minerals? I have had a memorandum prepared for me of the state of things with regard to the mining laws of the province of Biscay, in Spain, where my company has large interests. I will put it in for reference. In effect it is this: the mineral belongs to the state. Anyone, either a Spanish subject or a foreigner, I believe, may, what is called, "denounce" a mine, that is, bring to the notice of the state the fact that there is a mineral workable under certain property. He makes an application, and for a small payment he obtains the right to work this mineral just in the same way as an English landowner has the right to work his own minerals.

1896. What is the practical result of that? To show the practical result of that, I will give you our own case. In our case when I came into the company I found two sets of royalty owners. I found a set of royalty owners under the state, who were paying less than £100 a year to the state for the whole of the mines which we took over. I found that those royalty owners again had made an arrangement with some English people for a sort of sub-letting, and for the creation of an interest under them. I found that the English royalty owners had formed a company, which company I happened to take shares in, and became a director of. I found that we practically had two sets of royalties. First we had the English royalty owner; second, the royalty to the concessionaire from the state, who only paid less than £100 a year to the state. These royalties became so tremendously oppressive that we had to raise nearly £100,000 to get rid of the English royalty owner, who was sitting upon us like the old man of the sea. We got rid of him. We raised £100,000, and we cleared him off, and now we have the concessionaire, the royalty owner created by the state, in Spain, who is drawing £10,000 a year from the working of our mines, and I will undertake to say that that Spanish concessionaire has never spent £500 over the transaction. The state, which is the theoretical owner of the mine, is not getting at this moment £100 a year for which the concessionaire has got £10,000. That is the operation of the law there with regard to the state ownership of minerals.

1936. I think you said that you had had no experience of a sliding scale of royalties? I have not. We have often discussed it and we have felt that it would be a very desirable thing. I have had the experience of going to land owners within the last year or two and asking for concessions, and we have discussed from time to time the question of the sliding scale, and we, that is, the solicitors on both sides, have felt that we would not have had to be there if we had had a sliding scale.

1937. I understand you to agree with the principle that a sliding scale based upon the selling price would be very much more satisfactory, as it would render it unnecessary for a lessee to be making applications to his landlord in bad times, many of the applications possibly not being entertained? That is my opinion, given, however, without having had any actual practice. It is a matter of opinion in our district so far.

1938. Would that be necessary if the royalty was taken in low times? No; but then I would go further and say I do not see why a land owner should not have some little of the benefit of the high times. I think it is only fair all round.

1939. What some gentlemen would like would be to take it at the lowest and then get the benefit of the highest? I do not say that at all. I think you should find the proper stage. Let it go down as low as it may, it cannot go beyond a certain depth because when it has got to a certain point it is not profitable and the work must be stopped.

1940. Have you ever known any of the powers of the old Canal Acts exercised in your district? They have been exercised for navigation purposes, though not for other purposes within my knowledge; but I should say that I can only go back for 30 years or so myself. There has been nothing of that sort exercised in my time.

1954. You referred to Bilbao and the enterprises in which you are engaged there; that is ironstone mining, I presume? It is.

1955. Can you tell how much is paid as royalty; what is the total amount per ton on the ironstone in Bilbao? In our particular case I should think we pay at the present time something like £10,000 a year to the first concessionaire; as I tell you, we have got rid of the second royalty by the payment of something like £100,000.

1956. How much per ton would that be? My note here is that our mines pay the Government £56 a year, but that they were leased to our company under a royalty of 1s. 3d per ton and a dead rent of £5,000 a year.

2008. I think you said the rent you paid at Bilbao for Spanish ore was 1s. 3d. per ton? —Yes.

2009. Is that exclusive of the money with which the third man was bought out? Yes, we have to pay that independent of what the third man got.

2010. So that really your rent is a good deal more than the 1s. 3d. per ton? Yes, it would have been.

2063. With regard to the case of the Spanish mines, is it quite fair to say that what is the case in Spain is the necessary result of state ownership of royalties? Could you not imagine a case—perhaps there are cases—where the state would not give the concessionaire the power of subletting, and in such a case would not the state itself get the whole of the royalty? Your complaint was, I understand, that the state got less than £100 a year whereas you pay £10,000 a year for royalty; does not that arise, not from the state ownership of the royalty, but from a certain incident of the law in Spain which gives the first concessionaire power to sublet to a second royalty owner? No; there is very great difficulty in imposing a restriction on the first concessionaire. The first concessionaire, I think, must be left to make what he can of the property.

2064. That is just the point; why did you say "must be" left? I take it that the reason that the state in Spain has done this has been for the purpose of inducing foreign capital to come in and to work these mines as they have not capital enough in their own country.

2065. Would not the foreign capitalist be equally induced to come if the state confined the ownership of the mine to the actual worker of it; that is, if the state gave the concessionaire a right to the mine simply as long as he works, without giving him power to sublet to a third party? I only want to correct what I think is your too general statement that Spain proves the uselessness of the state reserving minerals? I have not considered all the results that would follow from a state-owned mineral property as against a privately owned mineral property. I merely wish to inform the committee about what happened as a matter of fact and practice in Spain where minerals did belong to the state.

2066. Would you not modify your evidence by saying that the evils of the Spanish system are owing to the existence of a power in Spain which enables the concessionaire to sublet? If that power did not exist, the state would get the £10,000 a year, and not merely the £100 a year, is not that obvious? Do you mean to say that if the state were to wait until the capitalists came forward to develop the minerals they might have got this money?

2067. That is how I put it? Then I say yes, if the state were disposed to wait as long as the state might have to wait till the capital came.

Alfred Barnes, M.P., member of the Commission, and chairman of the Derbyshire, Nottinghamshire and Leicestershire Colliery Owners' Association:

2134. I see from the answers that you do not have a sliding scale to any extent in your district? We have no sliding scales. I myself am not an advocate of the sliding scale. I think that we have got quite sufficient experience in the past to arrive at an average, and that both the lessor and lessee ought to know what the average has been, and that ought to be the basis for the future. I think it is merely a question of a small amount of capital. In the bad times it would not make a difference of 1d. per ton, and if anything so fine as 1d. per ton would stop a colliery I think it ought to be stopped. What has really been the means of bringing up this question of a sliding scale is the action of those people who have taken their royalties in high times. They naturally wish to come down to the low figure. They have taken their coal at perhaps twice as much minimum rent as it was worth and then in the bad times—of course things are better now—but in the last six or seven years they felt the shoe pinch very severely. That has been a great means of bringing about the outcry for a sliding scale.

2189. When you said that you did not coincide with those who argue in favor of variable royalty according to the selling price, that I think you said was because already the market had been so well established that there was no necessity for it? I think there is no necessity for it. I think as you have experience of from 30 to 40 years you can establish a fair average without having a sliding scale; in fact, it is practically the average result of a sliding scale you may say.

John Dixon Kendall, mining engineer and lessee of iron mines in Cumberland:

2484. You are interested in the hematite iron trade in Cumberland, I believe? Yes.

2485. What interest have you in it? I am acting as a mining engineer, and I am also a lessee of iron mines.

2488. You give us generally, I believe, what royalty is now paid upon ironstone? Yes, in the answer to question No. 7.

2489. What does it average per ton? It varies, of course, with the selling price. I have a number of instances here, no two of which are exactly alike. I have abstracted 16 leases, and have the figures with me which I will give you. Here is one dated 1886 with a minimum of 1s. 9d., it is never less than 1s. 9d., but up to 15s. the royalty is one-sixth of the selling price; from 15s. to 20s. the royalty is one-fifth of the selling price; from 20s. and upwards the royalty is one-fourth of the selling price. In the next one, granted in 1883, there is a minimum of 2s., but it is one-seventh of the selling price afterwards. In another, granted in 1875, there is a minimum of 2s., and the royalty is one-sixth of the selling price. Another, granted in 1873, but which has been determined, had a fixed royalty of 7s. Another, granted in 1862, had a fixed royalty of 1s. 3d.; that, of course, has expired. Another, granted in 1883, had a minimum of 2s. 6d.; that was when the selling price was 12s. and under; from 12s. to 20s., there was one-fourth of the additional selling price extra; and above 20s., one-third of the additional selling price extra. A lease granted in 1872 for 39 years has a fixed royalty of 1s. 6d.; another granted in 1875 for 1,000 years, has a fixed royalty of 2s., but the lessees paid a premium of £10,100 to the lessors. Another, granted in 1877, has a minimum of 2s. 7d. up to 13s.; above 13s., one-fifth of the additional selling price in addition. One granted in 1881 had a minimum of 3s., and the royalty was one-fifth of the selling price. Another granted in 1883 had a minimum of 2s. up to 12s., but the scale after that was a very complicated one. From 12s. to 12s. 6d. the royalty was 2s. 1d.; from 12s. 6d. to 13s., 2s. 2d.; from 13s. to 13s. 6d., 2s. 3d.; from 13s. 6d. to 14s, 2s. 4d.; from 14s. to 14s. 3d., 2s. 5d., and so on; it is an increasing fraction, and gets up to 6s. 4d. when the selling price is 24s.; then it goes on increasing 1d. per ton for every 2d. per ton increase in the selling price.

2492. If we were to take 2s. as the average royalty on the output, should we be far wrong? No, I do not think so, because the average price for the last ten years has only been about 11s. 9d.; that is for an average ore, so that the royalty on that would be about 2s., taking it all round.

2502. Cannot you give us the proportions in which it goes up? This is the way in which it is mentioned in the lease; there is no particular fraction. From 12s. to 15s. it is one-sixth of the selling price; from 15s. to 20s. it is one-fifth of the selling price; over 20s. it is one-fourth of the selling price. Another has a minimum of 1s., that is at 9s. and under; from 9s. to 12s. it is one-fourth of the extra selling price, in addition to the 1s.: from 12s. to 15s. it is one-sixth of the selling price; above 15s., one-fifth of the selling price. One made in 1887 has a minimum of 1s 9d.; that is at 12s. and under; from 12s. to 15s. it is one-sixth of the selling price; above 15s., one-fifth. Then there is one made in 1878 at a fixed royalty of 2s. 3d., which was determined on account of the royalty being too high.

2503. Is there always a fixed rent as well as royalty? Always a fixed rent, and that varies very considerably. I have known from 10s. 4d. per acre to £100 per acre.

2504. Is it the general opinion in the business that the sliding scale is the best arrangement to make? Yes, I think the lessees prefer it, unless, of course, they have a fixed royalty which would allow them to work in all conditions of the market. If you have got a fixed royalty which will allow you to work at any time, undoubtedly that is the best.

2505. I do not quite follow that; do you mean a very low fixed rent? A low tonnage rent. If your tonnage rent is low enough to allow you to work in depressed times, then undoubtedly that is the best so far as the lessees are concerned and so far as the district generally is concerned.

2506. That is, if the amount of royalty paid is small enough not to encumber the working of the mine? That is so. Of course if it is a high fixed royalty, then when times of depression come you simply have to surrender your lease. as has been done in some of these cases which I have given you. For instance, there was a case where a fixed royalty of 7s. was given in 1873, when iron ore was selling at 30s. to 36s.; when the iron ore came down to 13s. and 14s.. and even lower than that, they were obliged to give up the lease. There was another case in the same district where, in 1873, they actually gave 15s. fixed tonnage. That lease had to be abandoned in the same way.

2510. Those very high rents were, I presume, given in the time of inflation, when people were speculating? Quite so, when nobody ever dreamt that iron ore was coming down below 18s. or 20s., but the older leases which were fixed at 1s. 6d. and 1s. 3d. and 1s. and so on, were never broken, so far as I know, on account of the royalty being too high; the lessees were always able to work under those leases, but probably that was because wages were less than they are now.

2554. Speaking generally, do you consider that the system of royalties prevailing in West Cumberland has an injurious economical effect upon working the hematite ore in that county? Below 12s. I think they have decidedly. Above 12s., as a rule, I have not much fault to find with them, but below 12s. they are not only injurious to the lessees but to the district at large, for the reason that if the royalties were lower we should be able to work many mines or parts of mines which now we cannot work on account of the high royalty.

2555. Have you had an opportunity of comparing the royalties that are paid in Cumberland with the charges in the nature of royalties which are paid at Bilbao? Yes, I have.

2556. What is the result of your comparison? They are much higher in Cumberland. If you get a concession there from the government you have no royalty to pay for it.

2557. It is not that that I was alluding to. Of course, as you know, the actual payment by the people working the ores there is not to the government but to the persons from whom they get the right; to the original concessionaires or the persons to whom the concessionaires have parted with their rights? Yes; but I think there are many cases, some of them very important cases, where the concessionaires are working the mines, and they in a great measure, holding as they do important mines, rule the prices, because they can work at a less price than the other people who have to pay royalties to the original concessionaires. I know that some of them are paying as much as 1s. per ton royalty, others 8d., but there are some parties working very extensively who do not pay anything.

2573. Can you tell us what proportion of the selling price, assuming it to be as you say, from 12s. to 16s., goes in labor? Yes; I have worked that out. Of course, it varies a great deal, 1st, according to the price at which the ore is sold, 2nd, according to the quantity raised, 3rd, according to the nature of the deposit, and 4th, according to the freight. But taking an average case of hard ore, which is difficult to get, and taking the selling price at 9s., I find that the wages would absorb about 50 per cent. of the selling price, and the royalty 22 per cent., and that the lessee would get nothing.

2574. What about the balance? The balance is made up of materials, rates, taxes, and so on. The wages and royalty only make 72 per cent., but the remainder is made up of a number of incidental expenses. If you take the same class of ore at 10s. 6d., you get 43 per cent. in wages, 19 per cent. in royalty, and 10 per cent. would go to the lessee. If you take 12s. as the selling price you have 40 per cent. in wages. nearly 17 per cent. in royalty, and 20 per cent. to the lessees. Take 18s., and you will have 30 per cent. in wages, 20 per cent. in royalty, and 30 per cent. to the lessees; that is to say, as the price goes up the proportion that is paid in wages becomes less, and the proportion to the lessee becomes greater. whilst the proportion paid to the lessor is practically the same all the way through. Now if you take a soft ore at the same prices, that is, 9s., 10s. 6d., 12s., and 18s.; at 9s. you have 30 per cent. in wages, 22 per cent. in royalty, and 28 per cent to the lessees; at 10s. 6d. you have 28 per cent. in wages, 20 per cent. in royalty and 63 per cent. to the lessees; at 12s. you have 27 per cent. in wages, 18 per cent. in royalty and 37 per cent. to the lessees; at 18s. you have 18 per cent. in wages, 20 per cent. in royalty and 48 per cent. to the lessees.

2575. That is, assuming the same royalty in every case? Yes, the same royalty for the same selling price in each case. It is a royalty with a 2s. minimum I have been working on.

2576. And the same wages, that is, you do not take account of any rise in wages? Yes.

2577. Then you do take account there of the rise in wages? I may say these are not estimates, they are actual figures.

2578. You think there, I suppose, that the wage-earner gets also some profit from the increased selling value, but not at once; it comes later? Yes, he gets a rise in wages as the ore rises. but he does not get the same percentage of the selling price; his percentage falls as the price rises.

2579. Do his wages rise at once? Almost always at once; they rise at once and fall at once with us.

Alfred Hewlett, mining engineer and colliery owner in Lancashire:

2724. Have you any opinion one way or the other as to the advantage or disadvantage of a sliding scale royalty as compared with an ordinary royalty? In my own opinion I would much rather have a fixed royalty. I might add to this that so far as my knowledge goes royalties were originally fixed by a sliding scale almost entirely. That was the origin of the royalty so far as my knowledge of the history of mining goes. Then great difficulties arise. It is always unpleasant to have all your books looked at and everything of that sort; but it is a necessity in the case of a sliding scale. Complications arose and hence the fixed royalty came, and for myself I very much prefer a fixed royalty.

William Barrow Turner, member of the Institution of Civil Engineers:

3000. How long experience have you had in the hematite mining? Over 30 years.

3001. Will you describe the nature of the mining generally; is the ore found in veins? It is found in veins, but mostly in irregular deposits. There is very great uncertainty about it. You can always say where ore may be found, but it does not at all follow that you will find it. I may say that there is more risk than there is almost in any other kind of mining I know; in fact I have searched for ore myself about twenty years before I found any at all.

3006. According to the sliding scale which you gave us the royalty upon a ton worth 10s. would be 1s. 8d., the minimum being 1s. 6d. when the price is not exceeding 9s., and there being an advance of a penny per 6d. up to 14s. Therefore, at 10s. the royalty will be 1s. 8d., will it not? Yes.

3007. Would you have to pay in addition to that royalty of 1s. 8d. any wayleaves, either underground or surface? Yes, you will frequently have to pay an underground wayleave, which in many cases is rather an excessive charge, and for this reason, that the royalties are so much mixed up. You may have a field of a few acres, say four or five acres, with the minerals belonging to two lessors. In a case of that sort you would have to pay a double wayleave.

3008. You mean you not only have to pay a royalty for the right of working the mineral, but you have to pay a wayleave for bringing the mineral worked on the property of somebody else through that part of the mine which is the property of another person, is that so? Yes; and that you have to do sometimes twice over; it would mean in certain cases 4d. per ton. That is really a tax upon the royalty.

3009. You would have then in regard to the royalty to add 4d. per ton in some cases for underground wayleaves? That is so.

3135. About how much per ton is the royalty rent as separate from the wayleave? It varies; there are so many schedules. There is one which is a sixth of the selling price, with a minimum of 2s. That is a scale of our own which we have been working under for a number of years. There is also a schedule with a minimum of 1s. 6d. at 9s. and it goes on increasing according to a scale which from 11s. 6d. to 12s. makes it 2s.; at 15s., 2s. 3d.; at 18s., 3s. 9d., and so on. There are several scales, but they are all more or less similar, except where you have the 2s. minimum.

3136. Have you found the sliding scale advantageous? I think it is an advantage. It is an advantage in this way, that it enables you to meet the consumer at the low prices.

William Kellett, mining engineer and manager of the Barrow Hematite Iron and Steel Company:

3212. Are the sliding scales of recent introduction into Cumberland? Those that I have handed in have been more than 10 years in existence.

3213. Were they introduced on account of any depression in the trade? They were.

3214. Would you say that the sliding scale system has now replaced the old system of fixed royalties? I should think it is gradually doing so.

3215. Gradually? Yes; I think when any new lease is made a sliding scale is adopted.

3216. Is it your opinion that the sliding scale system is a better system than the fixed system? Yes, I think it is a fair system. I think it is fair to both sides if it is a proper sliding scale, a just one.

3223. Do you consider that the high royalty at one end of the scale at a high price is not balanced by a correspondingly low royalty at the other end of the scale? I do not think it is.

3224. Now, you suggest that the same principle should be followed whatever may be the price, and that a certain proportion of that price should always go to the landlord—an eighth, I think, was the figure you gave? Whatever the price is, whether it be an eighth, a sixth, or a tenth, or whatever it may be, I would follow that through.

3225. You would admit, however, that one mine may be an eighth, another a sixth, and another a fifth? Certainly; I think you must fix your sliding scale according to the quality of the ore, the nature of the mine, the quantity of water that you have got to pump, and the distance from the surface that you have got to raise the ore.

3226. The result of that would be that the lessee of the mine and the miner would derive a greater benefit when prices are high than the royalty owner? I think the royalty owner would have had his fair share of it all through.

William Gill, general manager of the Orconera Iron Ore Company:

3373. Does the state in Spain levy any other tax on the minerals than the royalty? Yes.

3374. A special tax I mean; not a general tax? Yes, a tax of one per cent. on the value of the ore at the quarry's mouth. The ore at Bilbao is sold free on board ship; in fact, invariably free on board or sold on this side; so that the value at the quarry's mouth is a fictitious value, and has to be appraised and valued. It is settled at present at so much. We have meetings from time to time with the treasurer, with the assessor, and we arrange that the standard for the coming quarter shall be so much, and upon that we pay one per cent. It comes to a very small amount for the large quantity shipped by the Orconera Company for instance, which has nearly 900,000 tons per year of its own ore, but I think we only pay about £1,800.

3375. You said, I think, that the greater part of the hematite mines at Bilbao are not worked by the original concessionaires, but have been leased or parted with in some way to other parties? Yes, I should say two-thirds of them have.

3381. I understand it then as comparing the position of the concessionaire of the mineral rights in Spain with the proprietor of minerals in this country, that the concessionaire who works his own concession would stand in the same position as the proprietor of minerals in this country who works his own mines? Exactly.

3384. The sum paid by the lessee to the concessionaire would be a payment of the same class as the royalty paid by the lessee to the proprietor of minerals in this country, would it not? Yes.

3385. Then can you tell us what is the amount of royalty paid by the people who are working the mines in Bilbao, the actual workers of the mines, to the concessionaires? Yes; it varies very much according to the position of the mine and its facility for transport, and the quality of the ore; but it may be taken to range in the very old leases made about 10 or 15 years ago from 8d. to 10d. per ton up to 2s. and 2s. 6d. for brown ore, and up as high at present, but only just recently, as 3s. 6d. per ton for red hematite, which is getting very scarce, and of which there is only a very limited supply; but that can hardly be taken as a fair test of royalties over the whole district, because the red ore is in the hands of two or three people.

3386. What is the price of red ore free on board? Now it has gone back a little, but a short time ago it was 12s. a ton free on board.

3387. And was the royalty of 3s. 6d. paid on the 12s.? Yes.

3388. Do you make that calculation including any lump sums that have been paid for buying up royalties? They vary very much. Occasionally a lump sum is paid; occasionally a premium is paid in addition to the royalty—for instance a man will give £2,000 or £3,000, or whatever it may be, and a royalty of so much.

Septimus Alfred Stephen, member of the Legislative Council of New South Wales:

3477. Could you tell us generally what is the practice with regard to the concession of minerals in New South Wales? Originally, when all the grants were made under what we call the Orders in Council, that is, before 1861, the grants did not contain in every instance the same reservation. Some contained a reservation of timber for bridges; some contained a reservation of all minerals; and some would contain a reservation of roads in addition. But in 1854 (I am speaking entirely from memory, but I am sure I am right on this point), a proclamation was issued by the Governor cancelling the reservation of coal, which had the effect of making the grants prior to that date contain no reservation of coal. In the Act of 1861 there were two different conditions under which lands were granted, one simply where you took up the land, and had to reside upon it for a certain number of years, when you did not get the coal or minerals; and the other called a mineral conditional purchase, where you had no residence clause, but after expending £2 per acre in mining purposes other than gold, and paying £2 per acre, you got a grant of that and with no reservation of the minerals.

3478. Does a large extent of the land containing coal deposits in New South Wales belong to private owners, under the system of grants which you have described to us? As far as I know, I should say that until within the last few years all the coal mines worked in New South Wales were held by private owners, either purchased under the Orders in Council, or else bought as a mining conditional purchase. I should think perhaps very nearly the whole of the land worked for coal was worked by private owners till within the last few years.

3479. Are those coalfields which are held byprivate proprietors worked by the proprietors; or are they let? In many casee a company has been formed, and the property belongs to the company who have bought the land right out. In other cases the owners of the land have leased it on a royalty of so much per ton. The royalty varies from 6d. to 1s., which, I think, is the highest I know. They pay 6d or 1s. per ton on all round coal, and on small coal I think 4d. is about the general price. That is the royalty paid to the owner of the land in fee.

3480. Is it customary to reserve what are called fixed rents also? Yes, nearly in every instance. The fixed rents vary. I know one case in which, I think, the fixed minimum rent is £2,000 a year. I know another where the fixed rent is £1,200 a year. I have known one as small as £450; but in that case I consider the fixed royalty was a very small one. I do not know any lease issued by a private person which does not contain a royalty.

3481. Could you give us the acreage in those cases? I could not tell you the exact acreage, but I think the royalty which I speak of as being £2,000 was for over 1 000 acres of land.

3482. It was about £2 an acre then? Yes. I have never known the principle fixed according to the acreage; it has generally been a matter of arrangement between the intending tenant and the landlord who has said, "I must have a fixed rent of so much, and I will not let it to you without."

3508. I think you said that it was not till 1884 that the Act was passed giving the Crown the possession and control of the minerals? In the 1884 Act there was a clause to say that for the future all minerals should be reserved in all grants; that was practically doing away with the M.C.P. clause, as it is known in the colony, which authorized persons to acquire the minerals by paying £2 per acre and expending £2 in mining other than gold.

3509. Can you say what led to the change from private ownership to state ownership? The colonists thought that, seeing that a large royalty was derived from these people who bought the land, they ought to have the right to reserve that for the state, that was the reason of it.

Richard Harris Williams, past president of the Mining Institute of Civil Engineers :

3833. What knowledge have you of mining in Cornwall? Very considerable; I have been engaged all my lifetime.

3864. . . I think the dues should be paid on the profits, and not on any given proportion of the mineral raised. Suppose that two mines are working side by side, or within the immediate district; one returns, we will say, 20 tons of tin per month, and leaves a profit of £500 per month; the other returns 20 tons of tin per month, and has to call upon the shareholders for £200 per month to keep it at work. Now, you see that the payment of dues there comes very hard on the parties who are paying more for the tin than it is worth. That arises from this fact that in the one mine, which is making a profit, the grade of ore is very high; in the other mine, which is making no profit, the grade of ore is very low, and it is only the hope of meeting with a higher grade of ore that this work is continued; the dues do come there with very great and severe pressure on the proprietors of the mine—unduly so, and help to crush them entirely, because it is the exhaustion of the shareholders' resources that shuts up the mine.

3889. Could you define what the profits are; do you think there would be any difficulty in defining them? No, I think not. I think that, if the books are fairly audited, there ought to be no difficulty whatever,

3890. The effect of it would be practically to make the lessor a partner? Yes, he would be a partner; but the lessor is the benefited party when often the adventurers lose all their money. First of all, there is the dead-rent. I have unfortunately worked mines that have returned so little mineral that the dues have not covered the dead-rent—the dead-rent being the full agricultural value of the lands occupied—besides paying £100 for what was damaged. Then, again, the people are employed, and the land and the houses become more valuable around the mine, and the markets in which the lords are generally interested more or less are better; whereas the shareholders lose the whole of their capital. Under conditions where the mine is, we will say, worthless, it would relieve the Cornish mines a great deal if the dues were paid on profits. If that relief was granted to mines or obtained by the mines a large number of mines which are now shut up would, perhaps, be re-worked, and it would revert to the lord's interests as much as to those of the shareholders.

3891. What proportion of the profits would you consider a reasonable rate of dues? I think that is a matter which should be well weighed over in all its relations, taking the average of the mines in the county which are paying profits. I think if there was a uniform rate laid down it would be only fair that that should apply to the whole of the mines, inasmuch as if the mine is paying an excessive profit over the outlay the parties associated in that mine are very often in a mine that is paying nothing. I look upon it on a broad principle, as if all the minerals belonged to one lord in the county.

3892. What should be the proportions? I think that ought to be well discussed and weighed over, but I should have thought that a fifth, or something like that—a fifth or a quarter part of the profits.

3893. Of course the lord would then be subject to good or bad management? That would be a very wholesome thing, because bad management would not be allowed; that would be good for the county, for the lord would come in to help to remedy the evils which ought never to be allowed to exist.

4102. Do you, therefore, think it would be fair for a landlord to be entirely at the mercy of his co-partners, as they would be in this matter; he holding, say, a fifth? No, I do not think so. I think the landlord should be fully protected in every way.

4103. In what way would you protect him? The landlord should be paid for the land at its freehold value, and 50 per cent. over, then he would have his dead-rent besides. Then you see the people are employed around him; his tenants are employed. Then, as far as the dues are concerned, the books would be audited, and the landlord would have full power to insert any clause relative to the management of the mine, or to the working of the mine.

William Rich, agent for the South Condurrow Mines, Cornwall:

4141. Did you hear the suggestion made by the last witness that it would be desirable that dues should be paid on profits? Yes.

4142. That is not a matter which this Commission can take into consideration, but at the same time we should like to hear what you have to say upon it? I do not think it is workable.

4143. Why? Because it would lead to an interference on the part of the lords, and it would be sure to create diversity of opinions, to say the least of it. I think it would be hardly fair to the landlord; I do not agree with it at all.

4179. Could you give me the reasons for which you think it would be unjust to the landlord to pay him a share of the profits? I should say that we have got trouble enough now with the landlord. I think the landlord would have a perfect right to interfere, and it would lead to further disputes about the profits, and how the mine should be worked.

4180. Would it not be to the interest of the shareholders to work the mine economically? Yes, certainly; but then there might be a difference of opinion with the lord upon that.

4181. If there was a difference of opinion, and if he had a quarter of the shares, would you not think it fair that the opinion of those who had the majority of the shares should prevail? Certainly; I should not like to give him a quarter part of the profits.

4182. Whatever it was, a quarter or a fifth? I do not believe in working with the landlord on the profits. I think the landlord should have certain fixed dues while the mine remains to be developed; let the shareholders take the profits, if any, and the losses.

4185. Do you think it is fair that the landlord should get a rent when there is no profit made? I should say so, a small rent, or a royalty which is the same thing, and then I would increase that royalty as the profits came up. You must look at both sides of it fairly. I do not think a low-letting royalty will hurt the mines in Cornwall. I do not think that, say, 2 per cent. on the gross produce until the mine pays would hurt them.

4186. Would you leave the fixing of the amount of royalty to arbitration? No, I should like the Legislature to step in there, and then let us get the best terms after.

4188. Supposing the parties differed as to what the amount of the royalty should be, would you let the court of arbitration fix the amount of royalty then? Yes, I have no objection to that.

4189. You do not think that that would be too great an interference with the right of the landlord? No; if the Legislature were to fix a low amount of royalty we should then know exactly where we were.

4190. But you approve of leaving it to the tribunal to fix the royalty? Yes, but not for any new ground, for mines that have been already worked. I do not go so far as to approve of it in the case of breaking up new ground. I speak of mines already worked, where the surface has been already opened and destroyed.

4191. Do you think that that would be quite fair to the landlord? I think so.

4192. Supposing the arbitrator said he is to get no royalty until a profit is made? I say I would limit it while the mine is developing, but he should have 2 per cent. at least.

4210. What standard would you take by which you would vary the dues as the mines improved? I should say that if we had to pay two per cent. during development, while our money is being expended, and then increase the dues to four per cent. when there are profits and dividends paid, and continue that four per cent. until all the capital is paid back, and then give the landlord five per cent. dues—I am speaking of the gross produce now—that would be about fair. I think we could stand that in Cornwall, and that it would be fair both to the landlord and to the mines. In no case should the dues exceed five per cent. of the gross produce.

4211. I am not altogether quite clear as to the exact meaning of the gross produce? That is everything sold out of the mine; the gross produce, regardless of cost; everything we return, whether it is sand, or tin, or stone, or ores or clay, everything we sell out of the mine, regardless of cost, is the gross produce of the mine.

Charles Fludyer, lessee of Violet Seton and Great North Seton Mines, Cornwall:

4342. You have said that you think the state should own the minerals of the country? Yes, I do.

4343. In answer to a question, you said you did not think it practicable to get the ownership conferred upon the state at present? I think not.

4344. Do you think it will be practicable at some time? Yes, I do.

4345. Have you any suggestion to make regarding how this notion of yours, to confer on the state the ownership of the minerals, could be made law? It depends upon the House of Commons a good deal, I think.

4346. In saying that you would give a fancy price to the surface owner for using his land to get that mineral, I presume yot do not mean us to understand by paying this fancy price you were recognizing his right to the minerals? I do not think he had any right to the minerals at all.

4347. Then you merely meant, by assenting to give this fancy price, that you would pay the price in order to compensate him for taking compulsory powers over his land? To compensate him for the compulsion; that is it.

4348. Then upon the state acquiring the minerals, I presume you would give no compensation to the present holders of the minerals? No.

4349. Would you give compensation in no case? Of course circumstances alter cases; there are cases, perhaps, of individual hardship which should be taken into consideration.

4350. Could you give me any idea of how you would deal with cases which the present holders have purchased during, say, the past hundred years? I should say that there should be some tribunal to settle that.

4351. Then your suggestion is, that an Act of Parliament should be passed, establishing a court for the purpose of deciding where compensation should be given and where it should not? Yes, in cases of individual hardship.

4352. I understand you to say, in answer to that question, that you would leave this court, instituted by an Act of Parliament, to decide what would be cases of hardship and what would not be cases of hardship? As Mr. Pendarves mentioned, there are men who have purchased a portion of the mineral rights, but have not any rights to the surface; such cases occurring within a certain stated period, say 100 years, should be considered.

4353. What about those who sold the surface, reserving the minerals under it? I would not give them any compensation—good gracious, no.

4354. You would not? Oh, dear no.

4355. You say that you would not compensate those whose families have held minerals for a number of centuries? No, I would not.

4356. Then you say they have no right to get compensation? I do not think that a landlord has a right to the minerals any more than he has to the rays of the sun or the fishes in the sea, or the air we breathe.

4357. If you say nobody has a right to the minerals, do you think anybody can sell a right in minerals? Well, they have done so, of course.

4358. If they had no right to sell, how could they sell it? It is the law of the land now that they should have these mineral rights, but I do not think it is a proper law.

4359. Then it is not as a matter of equity that you would compensate these people, but because they have taken the minerals from parties who have had no right to sell under the existing law; because they have made a purchase as they believe according to law? Yes, because they have made this purchase according to law within the last 100 years; the court should take into consideration the case of those who had made such purchases.

4360. Even though the parties from whom they made the purchase had no right to sell? Yes, even though they had no right to sell.

4405. Do you think the state, when it was owner, would treat its tenants as the generous landlords do theirs? It would do the same as Lord Robartes, I think.

4406. It would not try to get the best terms it could, but it would act charitably towards lessees? I do not know about acting charitably, but I think it would act fairly. I think it would be compelled to act fairly, because there would be a court, and that court would be answerable to the House of Commons.

4407. You do not think it would be its duty to make the best terms it could for the community, its *cestui qui* trust? I think it would be its duty to act fairly between the country and the man who lays out his money upon the development of the country, and lays out his money in the employment of the poorer class.

4408. Do you think it would be possible for the state not to think of commercial considerations, but to think simply of giving satisfaction to the lessees of its property? I do not go so far as to say giving satisfaction to the lessees, but I go so far as to say that it would do what is actually fair and right between those who invest their capital in developing their country and those who own the country, which, in that case, would be the people of the country

4409. Do you think you can arrive at what is a satisfactory term between the lessor and the lessee in any other way than by the bargain of the market? Yes, I believe that in those cases a court would settle the matter more fairly between the parties.

Josiah Thomas, member of the Commission, and manager of the Dolcoath mine, Cornwall:

4417. Can you tell us the history of the Dolcoath mine; how long has it been working? It commenced working in 1799 and has been working continuously ever since; it was formerly a very rich copper mine, but in the last 40 years it has been worked principally for tin. The lode in the upper workings produced copper, but with the depth the ore changed from copper to tin, and during the last 30 years we have not been raising any copper at all; it has been entirely tin.

4418. When would your last lease have expired? The last lease for 21 years would have expired in August, 1887.

4419. I believe the shareholders of Dolcoath have some complaint to make, or think that they have some complaint to make, in connection with the negotiations for the renewal of the lease, is that so? Yes; the complaint was this, that they received different treatment from that previously received by any set of shareholders in Cornwall.

4420. Will you explain the circumstances and the grounds of their complaint? About 4½ years before the expiration of the lease the shareholders applied to the lord to ask on what terms he would give a fresh lease for 21 years, and as the mine was so deep (being nearly half a mile deep, or over 400 fathoms) and the price of tin for some years had varied considerably, the shareholders thought that one-fifteenth, which they were then paying, was a very high rate of dues, and asked the lord to grant them a new lease for 21 years at one-eighteenth; that is one-eighteenth of the gross produce. After a few days a reply was received from the steward. This was the first written communication the shareholders had from him. The first thing he said was, and this is a quotation from his letter, "You must bear in mind that at the end of about 4½ years Mr. Basset will have this valuable property to deal with in any way he chooses, and that he is not bound to renew the lease at all. Mr. Basset will accept a surrender of the existing lease as from January 8th, 1883," that is 4½ years before the termination, "and grant a new lease for 21 years," which would virtually be 16½ years, "reserving one-fifteenth dues together with a quarter part of the future profits to be paid every 12 weeks until, exclusive of dues, he has received £40,000. You must consider these terms as final. If they are accepted Mr Basset will require a notification to that effect not later than the 1st day of April; if they are not accepted the negotiation must be considered as at an end and the lease must then run out." That, as I have said, was the first communication we had from the steward on an application for a new lease. He wanted us to resign a lease then, which had 4½ years more to run, to take a new one for 21 years from that date, pay one-fifteenth dues, which is what we were then paying and £40,000 in addition. When those terms were announced to the shareholders and afterwards to the public there was a great commotion throughout the country. Such terms had never been heard of before. Many of the shareholders in Dolcoath had also large interests in several other mines upon the same lord's lands which were making heavy losses, and they naturally thought the lord would have taken that fact into consideration in granting a new lease for Dolcoath. Dolcoath was a prosperous mine, as you may see by the returns which I have sent in.

4421. Do the returns show the profits? Yes.

4422. What were they? From the beginning of 1799 to the end of 1889 they were £806,217, and we had paid to the lord during that time £259,579.

4423. Do you refer to the profits divided? Yes; the profits divided amongst the shareholders,

4424. Will you pursue the history of the transaction? There was a great stir in all the neighborhood. Then there was a great deal of negotiation. A committee was appointed by the shareholders, consisting of some gentlemen outside the executive, some very influential gentlemen in the county, Mr. Thomas Bolitho and some others, and they had several meetings with the lord and with the stewards. After about two months' negotiations the best terms that could be obtained were a new lease for 21 years after the termination of the then existing lease (that was 4½ years more than the first offer), a royalty of one-fifteenth as before, and a payment in cash of £25,000. Those were the best terms that we could obtain, and we had to pay that money.

4425. Did the transaction have any effect upon mining enterprise in Cornwall? Very much so.

4426. Why? The outside shareholders appeared to have lost their confidence in the lords. I have known some instances of shareholders residing outside Cornwall selling out their interest in Cornish mines; some of them have gone so far as to say they would never take a share in a Cornish mine again if they were to be so treated by a lord.

4427. The reason being, as you explained before, that previously leases had been renewed as a matter of course? Certainly.

4428. And, as I understand, without a fine? Without a fine. This was the first fine; they did not call it a fine, they called it a premium. Fine or premium, call it what you like, we had to pay £25,000, and that was the first instance in Cornwall, that ever I heard of, of a fine or premium having been enforced.

4429. Do you mean, as a matter of fact, that leases in Cornish mines have been invariably renewed upon the same terms as before? No, I would not say always upon the same terms. That would depend somewhat upon the value of the mine at the time. I mean that they have always been renewed as a matter of course, without any question.

4430. And without a premium? Without a premium. This is the first and only premium, so far as I know, that has ever been paid in Cornwall.

4435. Then, as I understand it, the practice has been that although the royalty was subject to revision on the renewal of the lease, yet no premium had ever been asked for before? Never before; it was the first instance that I ever heard of. The way in which the steward put it irritated the shareholders very much; it shook their confidence, because he stated plainly, Mr. Basset "is not bound to renew the lease at all;" almost intimating that he might take it into his own hands.

4436. And the words created the greatest uncertainty and doubt? Yes; they shook the people's confidence, because there never had been any question before about the leases being renewed, and they had never thought it possible that a lord would take a mine into his own hands and work it.

4437. As a matter of fact, according to the legal construction of the lease, was the agent of the lord correct in saying that he was not bound to renew the lease? Yes; as the law now stands, undoubtedly, the lord can say at the conclusion of the lease, "Will you please leave the mine, I am going to work it myself." There is no law to prevent that.

4438. That is to say the adventurers or the shareholders, when the lease was made originally, did not request that a provision should be made that the lease should be renewed at the expiration of 21 years, upon terms equitable or otherwise? No; because it was always the custom of the country for leases to be renewed whenever desired.

4524. Will you tell us again what was the capital expended by the company in developing the Dolcoath mine? In the printed return I gave it as £45,252.

4525. What had the lord done towards the development of the mine, what service, what outlay, or what anything had he done for this amount of money received from the company? Nothing beyond this: in the period that I spoke of between about 1846 and 1853, when the mine was changing from copper into tin, the lord gave up some dues which he might have lawfully demanded. He did not contribute any money, but he did not take some dues which he might legally have taken.

4526. That would reduce the sum which he would receive? The sum which he was legally entitled to receive.

4527. Did he spend any money? No.

4528. Did he help the company to develop the mine in any way? Not at all.

4529. Still he got this amount of money? £259,579.

4530. If Mr. Basset had taken the mine and laid down a precedent in that way would that have prevented capital coming into Cornwall? Of course it would. Who would think of speculating a lot of money on a mine with only a 21 years' lease and with a prospect of being turned out whenever the lord chooses to do so? Nobody would speculate any more on such terms as those. It would stop all speculation in the county. As you may probably know, having visited Cornwall, metalliferous mining is very different from coal mining. We may work a mine for 15 years out of the 21 before we meet with anything of value.

4555. Do the lords in Cornwall, to any extent, conduct mining operations themselves? Not at all.

4556. Therefore mining in Cornwall has been developed altogether by capital found by other persons than the lords? Entirely.

4557. Excepting so far, the lords may be shareholders? The lords may be shareholders, but there is not very much of that now.

4558. Speaking generally, the capital sunk in mining enterprise in Cornwall is found by those who are not lords as well? Yes.

James Barnes, member of the South Wales and North Wales Colliery Owners' Associations :

5210. During the past five years in the Monmouthshire and South Wales coal trade. what proportion of the selling price have you paid to the landlord? That is a very fair question. The landlord has had from me on an average over 14 per cent. of the selling price. I will undertake to say that since we have had the Nantyglo leases it has been 14 per cent. on the value of the coal.

John Bell Simpson, member of the Institute of Civil Engineers, and past president of the North of England Institute of Mining Engineers:

10,203. Have you worked out from that return any estimate of the royalty for the whole of the coal mines of England and Wales? Yes I have applied the whole output of the country to this return ; the whole gross estimated rental of the whole of the coal mines is put down in this return as £3.601,386, and if we take the output as given by the Government inspectors at 153,596,360 tons for the same area, we arrive at the average rental of 5.63d. per ton , but as this is said to include in many instances fixed machinery and other things not chargeable with royalty———.

10,204. On the assumption that it is charged with royalty, but not properly termed royalty? Royalty, but not properly termed royalty ; it may be taken as exceeding the average royalty rent of the country, and we should probably find that if we had accurate statistics that even with all the easements hereafter referred to, the total rate throughout the country does not exceed 5d. per ton. That is based upon those figures.

10,176. You have collected information showing what the royalty rate per ton upon coal was between the years 1705 and 1804? Yes, I had the means of getting the terms of 58 leases between those periods, and I find that the royalty rate was about 4d. per ton on the output.

10,177. And from that time till now what is it? There does not seem to have been much variation that I can make out.

Stanislaus John Lynch, Senior Land Purchase Commissioner under the Act of 1885 (Ashbourne Act) :

11,768. The law in Ireland is the same as the law in England in respect to giving the property in the minerals to the freeholder of the surface? Yes, but in Ireland we have a very considerable number of estates, especially in the north, and in portions of Kerry too, which are held by the present landlords under fee farm grants and leases for ever, sometimes there being two or three superior leases or grants between the owner and the fee simple one above the other, and in these the mines are usually reserved, that is royalties are reserved. In such cases of course we would only convey what was the immediate grantee's interest excepting the mines.

11,780. Can you give us any idea as to what number of sales have taken place under the Ashbourne Act in those districts which you consider to have mineral capabilities? Have there been a large number of sales already? Very large sales. Now, in the Queen's county we have very large sales adjacent to those coalfields.

11,781. Have you seen any probable difficulty in these sales having taken place in the event of the minerals becoming more worked? In my opinion the minute subdivision of land and the vesting of the royalties in small proprietors would effectually stop any development, or certainly impede any development of the mineral resources of the country. I think the difficulty would be this: In the first place the majority of the small tenants have not the intelligence to see the advantages to them of such development. Then, again, when they become proprietors they become naturally conservative about the rights which they had purchased and which are really their agricultural holdings, and they would perhaps think that it would interfere with the working of their farms.

11,795. Have you considered how the difficulty which you have pointed out in respect to the small patches of land which have already been bought could be met by legislation? In my opinion any future legislation which would vest in the state or in any department of the state the mines and royalties would have to be to a certain extent compulsory so far as when there was an agreement for the sale of the entire estate ; the landlord would be bound to deal with the Government or the state authority for the royalties. Then again, I think the power could be taken to acquire from the existing tenants at whatever was the value any mineral royalties that exist. You must first ascertain that they are there ; they can suffer no damage ; they must get compensation.

11,796. What do you mean by tenants? I mean, of course, tenant proprietors.

Charles Stewart Parnell, M.P. for the city of Cork :

12,667. Can you give us any idea of the probable development of the mineral resources of Ireland generally, or of your own county in particular? The mineral resources of Ireland, generally speaking, are extremely limited, but there are places where mines could be started and developed with every prospect of success. These places would require to be carefully selected and worked with judgment owing to the nature of the case and the fact that the mineral resources of Ireland are so limited and, comparatively speaking, poor. In some cases the mining industries of Ireland have been kept back by the action of the owners of land in refusing royalties and refusing to let their royalties on any terms whatever. In other cases the mining industries have been kept back by excessive royalties being demanded. I myself know of one case in Wicklow where I wished to open a mine in the Wicklow mountains far away from any cultivated land, and where no surface damage could have been by any possibility done. It was an iron mine. I applied for the royalty and the owner, a gentleman of considerable landed property in the county, a neighbor of my own, declined to allow any mines to be opened on his estate on any condition whatever. In another case where I had leased the royalty, the royalty amounts to more than the profit and renders it impossible to open or develop the mines.

12,680. You are thoroughly acquainted with all the Acts relating to the purchase of land in Ireland? Yes.

12,681. And you are aware of what has occurred under Lord Ashbourne's Act and the extension of Lord Ashbourne's Act? Yes.

12,682. Have you any view as to the possible effect upon the development of the mineral resources of Ireland by the sub-division of land that may be created to a very large extent under the operation of these Acts? I do not think the multiplication of owners contemplated by these Acts will render the development of the mineral resources more difficult; on the contrary I think these Acts will facilitate its development because I think the small owners will be more easy to deal with than the larger ones; at all events probably the majority will be more easy to deal with and the result so far will be beneficial. But undoubtedly there will be many cases where it will be impossible to approach the new owners or to obtain from them fair terms as regards the development of the minerals; and I think the principle is certainly a false one of allowing the mineral rights to be owned by the surface owner, and especially in the cases to which you referred. It is scarcely within the intention of the Legislature to give the mineral rights to the owner of the surface. I think it is only the intention that the agricultural and surface rights should pass. I think it would be very desirable if the Legislature were to take powers to put these royalties in the hands of some local authority instead of transferring them to the future owners. If we had county boards in Ireland that would be the authority that would be indicated to my mind as being the most suitable to look after such a question and to own the royalties which they might let and which they then would be able to let and deal with on a systematic plan, and that the proceeds of these royalties should go to the reduction of the county and other rates, and they might be used for educational purposes.

12,683. Therefore your view would be that the ownership should be in the state, but the public generally should have the mineral rights when those purposes that you mention are met? Yes, I think the local authority in every case would be the best fitted to deal with the mineral rights when acquired.

12,684. When you say acquired them, your view I take it to be is that in the settlement of this purchase under the Ashbourne Act, neither the landlord nor the occupier should have anything more than the surface value of the land—the mineral value does not come in? Quite so.

12,685. Therefore there would be no hardship to either side if the mineral right was reserved to the public. Would that be expressing your view? I think it ought to be clearly reserved to the public. I think that would be the most advantageous while it would be more easy to deal with the new owners than the old owners.

Andrew Sharp, secretary and agent for the Coal Miners' Association in Cumberland:

13,379. Have you ever considered the question whether the royalties ought to belong to the state and not to private individuals; did you ever think of that? Yes.

13,380. What is the opinion generally upon that, do you think? There are a great many who have purchased them and who have legal claims, and I do not think we could hinder that by taking a sweeping view and taking things from people without proper compensation.

13,381. You would give proper compensation? Yes, I think they ought to be compensated to some extent.

13,382. Have you ever thought whether you would wish the whole business to be managed by the Government or not? I think that the royalties ought to be managed by the counties. I believe the county council as now appointed would be the best authority to have the dealing with the royalties similarly as they deal with the assessment of rates. They know the local circumstances of every county.

T. F. Brown, mining engineer, chief mineral inspector for Her Majesty's Commissioners of Woods and Forests, and Deputy Gaveller of the Forest of Dean:

13,950. What governs the royalty? Is it the quality of the coal or the distance from the port, or what? There are a great many circumstances. One element is the time at which the royalty is taken. For example, if it is an entirely undeveloped district, without railways and so on, a lessee would perhaps obtain a royalty on exceptional terms; but apart from that, where the district is developed the royalty depends on a variety of circumstances: whether the coal has to pay wayleave, if it is very deep or not, whether the quality is good or the roofs are good or bad and so on. In fact, practically all the circumstances that go to make a colliery more or less profitable operate in fixing the royalty. The element of competition also enters into the calculation.

14.019. Have you many arrangements for a sliding scale in Wales? Wherever we can we introduce the sliding scale, but we find the lessees object to it.

14,020. Why? For this reason, that the present system really operates in their interest as a sliding scale which does not slide upwards. When a new coalfield is acquired, it is acquired on a fixed royalty. Then the lessees work out the best seams and then they go to the lessor and say: "Now, we cannot continue to compete with our neighbors, we have worked out the best coal and we must have a reduction." and the lessor has to give a reduction; so that practically there is a lessee's sliding scale in operation in South Wales which only slides in favor of the lessee.

14.979. I think you said that you were now mineral advisor to the office of Woods and Forests? I am.

14,080. That is to say, in respect to those mineral properties which are in the hands of the Government and are managed for the Government? That is so. I also act specially and have done for 25 years for the Crown in the Forest of Dean.

14,081. I believe the customs of the Forest of Dean are totally different to any other customs almost in the world? They are very peculiar; the tenure is an exceedingly peculiar one.

14,082. Is it not in the nature of a privilege, giving mineral rights to persons born within a certain area? Yes; workingmen born within a certain hundred have power if they have worked a year and a day in a mine to come to me to be registered, and then they become what are called free miners and they are entitled to apply for a grant of an area or a royalty of coal or iron, the first applicant being entitled to a grant. The area of the grant is within the control of the gaveller and deputy gaveller, but the royalties in case of dispute can be settled by arbitration. The royalties only remain in existence for 21 years, when they can be readjusted either on the application of the Crown or on the application of the galee; and in case of dispute it may be referred to arbitration.

14,083. What is the principle on which the royalty is assessed? The basis of the maximum of the royalty is the right which the Crown has to put in a fifth man to work after the mineral has been won. The effect of that is that as regards a shallow mine or a shallow colliery the free miner secures a considerable interest; but as regards a deep mine, where the capital outlay, is great he has to give up or will have to give up the whole of his interest to compensate the person who sinks.

14,048. What happens with regard to those rights which the free miners obtain; do they work them themselves? No.

14,085. What do they do? Immediately a free miner acquires a right over an area he goes into the market and endeavors to sell on the best terms he can get to a man who may be either a speculator or a man of capital who is going to open; if he is a speculator he holds it with the hope of being able to sell to some one else at an improved price; if he is a person who puts his own money in and is going to work the mine of course he proceeds at once to work.

14,086. In point of fact he is in very much the same position as a concessionaire would be in Spain or in any of those countries in which the minerals belong to the Crown and are given to concessionaires on application? Yes, that is the simple operation; the result has been most fatal to the development of the Forest of Dean.

14,087. Will you explain how it has been so injurious to the development of the Forest of Dean? To begin with, the minerals were sold to speculators; the speculators went to the banks for loans on the security of these properties; the banks I suppose had not appreciated the unsoundness of the properties. but the time came when those minerals had to be opened under the rules and regulations or they had to continue to pay rents without any result. As time went on the banks became aware of the unsound nature of the property, and they of course brought pressure to bear and the result was a general collapse of the whole thing.

Rossiter Worthington Raymond, Ph. D., secretary of the American Institute of Mining Engineers:

14,278. For how long have you been secretary of the American Institute of Mining Engineers? I have been secretary of the American Institute of Mining Engineers since 1884, and I was formerly president of that society.

14,279. I believe you are a mining engineer? I have been a mining engineer in active practice for twenty-eight years.

14,280. You have also been a government inspector of mines for many years? Yes, I was for some eight years the government Commissioner of Mines and Mining in the states and territories in and west of the Rocky Mountains.

14,281. You are editor, I believe, of the *Engineering and Mining Journal* of New York? I was editor of the *Engineering and Mining Journal* of New York from 1866 until some time last year.

14,282. And you are largely interested in mining undertakings? Yes, I am the consulting engineer of the house of Cooper, Hewitt and Company of New York, which is largely connected with the mining of iron and coal, and with the manufacture of iron and with the manufactured forms of iron.

14,316. . . The system of mining—that is to say as to whether the miner, the actual operator of a mine, owns the land or not, is, I should say, something like this: Most of the important mines on the public domain, the gold, silver, copper and lead mines on the public domain, are operated by persons who have bought them from the original patentee, or who have bought the original possessory title and have got it patented. Generally if you wait until the mine is developed so that you know it is worth putting money into it you pay something for it, and what you pay for it is a sort of capitalised royalty, but you do not pay it to the government; you pay it to the man who was lucky enough to have got that thing from the government at five dollars an acre. He raises the price from five dollars an acre probably to $50,000 if he happens to have the luck to find the thing, and if you pay him $50,000 for it apart from the money you put in then to the mine with machinery and so on, you are paying what you are willing to give in a lump sum instead of undertaking to take it from him for fifty or ninety years, and pay him so much a ton on the ores you get out. There are, however, a great many cases of the public lands in which a regular tonnage or percentage royalty is paid. Those are generally cases in which the first adventurers have lost money; they have made a mistake or have had bad luck; or, after having made dividends for a while, they have got into a poorer part of the mine and stopped paying, and not wishing to put up any more money they call a halt. That is the case with a great many of the English companies which are operating in our country. One company, of which I am now president, and which was originally the purchaser of patents from the patentees——

14,317. I presume you use the term patentees in the sense of grantees? Yes, grantees under the patent. We call them patentees. Those grantees sold to us for a large sum of money, and that was our amortization or a lump sum for a future royalty. Well, we had got a great deal of money out of the mine I am thinking of now——

14,318. What class of mine was it? It was a silver and lead mine. We had taken out something like $5,000,000, that is £1,000,000, out of the mine, and paid a good many hundred thousand dollars in dividends. We had exhausted the particular beds of ore that we knew anything about, and we are now exploring to some extent on our own account, but to a still greater extent we are allowing other people to explore upon lease. They come along and say they would like to spend their money. I feel that we have not got enough to waste and I let them. Now, these things are arranged with no other authority to settle the terms than a free contract between the parties. The terms will vary very widely according to the risks and costs of the operation. A man comes along and offers to mine in a place where I do not think he will ever find anything in this world, but I am willing to have it explored, only I hate to do it with my company's money. I say to him, If you will mine there you need not give me but ten per cent. of what you get; you may have the other 90 per cent. The next man comes along and he wants to mine in a place where we both of us know there is ore, and I simply let him have it on lease rather than go to the expense of keeping up my organisation to work that particular part of that mine myself, and I make him give me 25 per cent., 50 per cent. or 75 per cent. of the gross proceeds.

14,319. What lease do you give? We generally give a lease ranging from six months to two years; nothing much longer than two years. That, however, is simply owing to the peculiar state of this particular class of cases, namely, companies owning a property who do not wish to surrender the control of it, who merely for the present, until something can be found, are willing to let somebody else spend the money and to make it an object to find the mineral.

14,320. That is a sort of search note then; it is only a lease for searching? That is what it is; but we are obliged to make it long enough so that if something is found the adventurer who takes a lease will have time to recoup himself. We say: Here, if you can find a good thing you can make enough of it in a year. In such a case as I am describing the owners would not give more than a year unless crowded to it by inability to find lessees who would take the adventure on such terms. I mention such cases only as examples apart from the offer of a lump sum in lieu of royalties, which may be perhaps held to be in the nature of the first payment of a purchaser of a mine. Apart from that I say royalties are only paid as such in the west, generally for what we call "chloriders," because they go round picking out the rich chloride of silver ore from a mine after it is otherwise exhausted, and they generally get hold of the companies who have seen better days and are in trouble, and who temporarily go into that system to keep things going. In the east on the other hand our iron lands and our coal lands are almost universally worked upon a regular system of mining leases under royalty. Such a lease is usually for twenty years at least.

14,321. The grantor being the person who owns the surface and the minerals? The grantor is the person who owns the surface and the minerals with it. On the regular English common law the boundaries so let are the vertical boundaries.

14,322. That system is exactly akin to the English system, is it not? So far as I know, barring a great many long words in an English lease. I think we manage to get at it in shorter language, but it is precisely the same condition. We have what you call short workings; we have a different name for it, but it is the same thing: that is to say a dead rent or mine rent is fixed as a minimum. The way in which we usually express it is: That the lessee (we will suppose now that we are dealing with an ironstone mine) agrees to pay quarterly or semi-annually at the rate of so much a ton of iron ore removed from that property; and he also further agrees to take away every year or pay for so many tons. If he does not take them away he pays for them. Then it is further provided that if in any year he does not take as many tons as he has paid for, he may make up that deficit at any period during the term of the lease. There is a little difference here, I think, as compared with the general practice in England. You have what are called "breaks" in the lease; a deficit must be made up within three years or four years, or five years possibly; we give the whole term of the lease; but this clause provides that the minimum mine rent shall be paid. I cannot make up my short workings at the cost of the mine rent. In any one year I must always pay the minimum rent, and that being done I am entitled, if I choose to do so during the period of the lease, to carry away as much ore from the property as I have paid for.

14,323. I think you were going to tell us what rents are usual? The average royalty in the United States is about 2s. per ton on magnetic iron ore and somewhat less than that on hematite ore because our hematite ores, which are mainly the brown hematites, are not so high in iron as our magnetic ores. Our magnetic ores average over 50 per cent. up to 66 per cent., and our brown hematites run from 28 or 30 to 40 or 45 at the most.

14,324. As regards coal, what are the rents? There are three classes of coal mines in our country which really have to be distinguished in this matter. The first is the anthracite coal, which has its own system both of mining and of wages and royalty. The next is bituminous coking coal which will make coke; and then the third would be all the other coals, including the non-coking bituminous coals and the lignites, which are merely steam fuels and domestic fuels. With regard to the third class, the lignites, which lie mostly in the Rocky Mountains in the west, they are not mined under royalty; they are mined by parties who have taken up the land because the government sells the land very cheaply; and if there is any royalty paid there it is in the form of a lump sum by practically a sub-purchaser, who purchases from the original locator. With regard to bituminous coals, I think the royalty ranges from about 5 cents (that is 2½d.) to 10 cents a ton. I know that I am mining—at least our house is interested in mining—large amounts of bituminous coal at a royalty of five cents, but I believe they are considered to have a very favorable lease. They took hold of a property which was neglected and producing no income, and this low royalty, coupled with an option to purchase, was given to them as an inducement. I judge therefore that that may be a low figure. With regard to the anthracite, the royalty is based upon the class of coal which, as you know, is very carefully crushed, cleaned and sized before going to the market, and the royalty is calculated upon the amount which is actually sent to market, not upon the amount in the ground and not upon the amount at the pit's mouth, and not upon any coal which is consumed in the mining operation itself. The latter is, however, usually waste coal; because they want to sell all that they can and they burn the refuse. Now, my impression is that these classes range from 5 cents, that is 2½d., which would be on the smallest sizes up to perhaps 40 cents a ton on the best quality and the finest and most expensive sizes of coal in the best collieries. With us the royalty always settles itself according to special advantages. The lowest royalty is the royalty that must be paid or else the landowner himself would not care to let the mine be worked. On the top of that you have all these higher royalties coming in to represent special natural advantages.

14,340. . . We cannot write down the rule which will fix the rate of royalty, nor can we safely interfere, under our conditions, with the free contract of the owner of the soil to hold on to or to segregate his mineral rights, and the only remedy for a possible inconvenience hereafter, such as has not yet been encountered, would of course be that the state (in that case the state of Pennsylvania) should assert a right over these minerals. Well, gentlemen, I do not know what conditions that would involve. With us it would mean confiscation and anarchy. If there is anything that the state has done, it has been to recognize the right of property in the coal as well as in the land, and it might as well go the whole figure with Mr. George, and assert ownership in the land and wipe out all private property, as to begin in that way. I suppose the safety of the people is the highest law, and that there might be a condition in which the state ought to do that or anything else most terrible, but with our conditions we have got to get a great many hundred years further on towards ruin before it will be necessary for the state of Pennsylvania or the United States to confiscate private property.

14,341. I did not like to interrupt you, but I should like to ask you a question in reference to your statement that the royalty was 5 cents, on an average, up to 40 cents. I should like to know what proportion of the selling price that was, if you could give it? I suppose you would say the selling price at the pit's mouth?

14,342. No, the selling price on which the royalty was calculated? The royalty is rarely based on the selling price. I have heard of a few cases in which anthracite royalties varied with the selling price at Mauch Chunk or New York. But in these cases, as in all others, the royalty is calculated on the weight—on the tonnage.

14,343. I thought you said that it was on the coal that is sold in the market? I said on the amount of the coal sold in the market. For instance, we have got underground so many thousands of tons of coal. Now, our anthracite mines are terribly wasteful by reason of the necessary preparation of the coal for the market. To us poor fellows who mine the coal, it sometimes seems as if the public were altogether too fastidious; they want it sized carefully and done up in tissue paper. We have to separate it into different sizes, clean it of dust and slate, and so on. Then, our system of mining in these very thick pieces is necessarily wasteful. We are improving it all the time, but we cannot work long-wall, and we have to leave pillars, and we often lose them by a crush. From first to last, as a general proposition, up to five years ago, at least (I hope we have made great improvements in the last five years), the general history has been that, out of 1,000 tons of coal in the ground in the anthracite thick seams in Pennsylvania, one-third stayed in as pillars and never came out; another third was wasted in the breaker, and got into the culm heaps with the slate waste; and the third was all that got to market. Now, no royalty has been paid on anything but that last third. If a smaller royalty could have been charged, and based upon all the coal hoisted to the surface, or even upon the measurement of all the coal underground, there would have been a pressure upon the lessees of our anthracite collieries to be more economical about the coal. But the coal they were wasting was not their coal. It was the coal of the landowner, and they were not charged any royalty upon it, and it was easier to waste it, and let it go; therefore we got no hold upon that thing to reform it, until these great companies, like the Philadelphia and Reading, and the Lehigh, and the other great companies mostly connected with railroads, began to acquire these lands for themselves either by the fee simple or by long leases, which made it worth their while to economise the coal. Since then we have begun to improve in economy, and we have made very great improvements within the last few years. That is what has saved the anthracite country from a tremendous waste and ruin. Up to the time when these great companies got the proprietorship and the colliery operators began to be at the same time practically owners, either by such long leases or else by fee simple, up to that time the anthracite region was exactly what Mr. Henry George would call paradise, but others might describe by a different name. The whole pressure of taxation and business interest was towards immediate product, and the land lay there wholly in the hands of occupants who gutted it and ruined it. It seems to me that that system is thoroughly illustrated as applied to mining land by the experience of the anthracite country.

14,344. Then as to this 2½d., what was it charged on—was it charged on the ton? On the ton. But that is the royalty I named on bituminous coal, not on anthracite.

14,345. On the saleable ton? Yes, on the ton sold.

14,346. What did the ton fetch? The trouble is to answer what it brought at the pit's mouth, and that, I suppose, is the place where you want it priced?

14,347. Yes? The difficulty is, that the price at the pit's mouth is determined by the price at tide water, minus the cost of transportation to tide water, and varies for every colliery according to the distance it is from the point where these prices are fixed. I would say, therefore, for our colliery, that it was an average colliery in the anthracite country, and that the average price obtained by us at the mine of all classes of coal——

14,348. On which the royalty was paid? On which the royalty was charged. They are ranged up and down, but it was about 1 dollar and 30 cents a ton, and the average royalty on that would have been about 25 cents.

14,349. I do not quite understand what that is? One dollar and thirty cents is a little over 5s.; 5s. 6d. we will say was the price for the average of our coal. Taking all the money I get at the pit's mouth for the coal, taking the weight and not minding the different classes, I think the average came out at 1 dollar and 30 cents, or 5s. 6d. Then the average royalty on that, if I had been paying royalty in that form on all the coal, and I was not, because my company had the fee simple (I am now thinking about the royalties actually paid around there), the average royalty on that would probably range about 25 cents, that is about 1s. out of 5s. 6d. One of our largest operators, Mr. Eckley B. Coxe, who mines something like 2,000,000 tons a year, I think, pays on the average about 1s. 3d. royalty on his coal, going as high in some cases, I am told, as 2s. or even 2s. 6d. per ton, where the mines leased have improvements. He has very fine coal, and he has splendid collieries and beautiful veins.

14,350. You are speaking simply of anthracite, I presume? This is all anthracite: with regard to the bituminous coal, I think, as I said before that probably 2½d. is a low average royalty. Much more might be charged, according to the location of the mine.* Upon limestone, used as a blast furnace plug, we pay, in the east, 2½d. per ton, or more, if the quality or the advantages of the quarry call for it.

14,358. Do your royalties ever vary by sliding scale? I do not know how that is in the bituminous coal country, but in the anthracite country I have never known of it, and with respect to iron mines I have known it in a few cases only. It is purely a matter of habit and custom, you know. They could be varied that way, and I have taken one lease myself in which they were varied that way.

14,359. Could you give us the terms of the sliding scale in that case? I cannot remember them, but I can tell you practically what they amounted to. In that case it was a magnetic iron mine in the state of New Jersey; the royalty was so fixed on a sliding scale that when iron was about the average range of prices with us the royalty would be about the average royalty of 2s., but as we have had some bad years in iron this lease provided that the royalty should drop with the selling price of pig iron. It was not based on the price of the ore, because there is no regular market quotation for ore in our country at all. There is a market quotation for pig iron, which can be ascertained. This was a rough calculation, by which we assumed that so many tons of the ore would be required to make a ton of pig iron, and that every fall of so much in the ton of pig iron would affect the value of the ores so much, and the royalty went down. I think, in a rough way, we divided it evenly with the lessor. If any fall took place in the price of a ton of iron we split the difference with him.

14,360. What did you assume to be the price of pig iron when the royalty was 2s. a ton on iron ore? The price of pig iron, for what we call grey forge pig iron, which is not the foundry iron, nor the white iron, was about 20 dollars; 18 dollars, I think, more nearly.

14,396. Then in the large coalfields within the states I take it that there must be a large amount of coal worked by those who are the proprietors of the mines, and who do not pay any royalty, and that other fields are worked by those who pay a substantial royalty? Undoubtedly the two classes exist, and, as I said, on the whole, I think the tendency is to work under royalty. I think, in other words, that coal operators do not care to own the land and be burdened with the management of the land.

14,397. In the market, if the coal from two mines is of the same quality and same kind, and the same distance from the port of shipment, will not the coal from those two mines sell at the same price? Certainly. Nobody knows with regard to any given coal whether it is mined on royalty or without royalty, by the proprietor or by a lessee; and what is more, all our great coal-mining companies are mining in both ways at the same time and they are mixing the coal in the cars.

14,398. They do not ask and take a less price for the coal that they raise out of a mine for which they pay no royalty as compared with the coal they take out of a mine and for which they pay a royalty? No; on the contrary, permit me to say, that most companies, and notably in the case of the Philadelphia and Reading Coal Company, which you Englishmen ought to know something about, because you have got a lot of money in it, the coal on which they pay no royalty has cost them so much that it ruined them, because in avoiding the payment of a royalty they went and bought the land, and they paid a lump price down in lieu of the royalty. Any man who owns the land is dragging along in some form or other the interest on the money which it cost him to buy the land. The Philadelphia and Reading Company borrowed $50 000.000 to buy 100,000 acres, and paid that money and gave bonds for it, and the Reading Railroad Company guaranteed the bonds. The whole thing went down in ruin together, because they were trying to mine the coal without paying royalty, having paid in lieu of royalty $50,000.000.

14.452. Am I right in concluding that, with your great and varied experience, you are of opinion that notwithstanding the royalties you have mentioned as being paid amounting to as much as 20 per cent. of the value of the product, the payment of royalties has not in any way retarded the development of the minerals in the United States? I think it has assisted the development of the minerals of the United States. My reason for saying that is, that I have had a chance of observing in the western United States for a period of nearly 20 years the operation of a system without royalty, namely the system of free licence to mine on the public lands, and I have found there that an element of stability and progress and of real regulated industry was introduced when these public lands were made private property, which is only to say in other words, when they were made subject to private royalties. It seems to me that in our country, so far as we have got with the question, waiving all difficulties, which you may have encountered in your more advanced position of development, in our country it is perfectly well illustrated that private property and the enlightened self interest of private owners is a far better atmosphere for the development of a regulated and a prosperous industry than any amount of free gift on the part of the state. We went and made every mine on the Pacific coast from the Rocky Mountains to the Pacific Ocean free of royalty, and we just had chaos, anarchy, and no progress, no stable order, no clear and definite title. Then we went laboriously to work, and have at last got it round so that the principal mines are in private hands, and they charge whatever royalty they can, and we have got more industry and more safety and security and profit by introducing the principle of private responsibility and private interest. Until anybody can show me a case where the opposite has taken place, I must confess that I feel as if that was for my country in its present condition a conclusive answer to the whole subject. I have been accustomed to say at home over and over again, that it would be better for the United States to-morrow to give up all its mineral land and deliberately convey it to individuals for nothing, in order to have somebody own it instead of the government.

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*In an appended supplementary note Dr. Raymond explains that his statement of royalty on bituminous coal in his evidence was based on a single district, where royalties are exceptionally low. He finds, on comparing rates elsehwere, that they vary from 5 cents to 28 cents per ton. A common royalty is 14 cents. Where the operators own the land, having bought it cheaply, the royalty is of course lower, or not reckoned at all. On anthracite coal it ranges up to 60 cents per ton, and the average may be between 30 and 40 cents. He is of opinion that 25 cents would be a fair royalty for coal land not already developed or improved.

Mr. John Bramston, Assistant Under Secretary of State for the Colonies:

15,196. You are Assistant Under Secretary of State for the Colonies, I believe? I am.

15,197. And you have been kind enough to look through some "Notes on Mining and the Law as to 'Ownership of Minerals in India and the Colonies,'" which we have had printed? Yes.

15,198. You have looked through them, I believe, with a view of telling us whether, so far as your information goes, these notes are correct, or of supplementing them if you are able to do so? Quite so.

15,199. I think the most convenient thing to do would be to take this memorandum, and go through the colonies which appear upon it. First, what information have you about Ceylon? The Act which is quoted in the notes—the Ceylon Ordinance, No. 7 of 1882—has been repealed by a subsequent ordinance, No. 20 of 1890, but the note is substantially correct, for mining for gold, silver, gems, or precious stones is prohibited except by the holders of licenses. The fee for a license is 5 rupees, and there is also a fee of 75 cents for the permission to employ any person in or about a mine. I find that on plumbago there was a royalty on export of 25 cents per cwt.

15,200. Do you mean by royalty on export a duty on export? Yes, but I think they call it a royalty; it is really a tax or a duty upon the export of plumbago.

15,204. Then Labuan? In Labuan, leases after 1849 are subject to a royalty to be fixed by the Governor in Council, and that royalty is to be levied upon all coals and other minerals.

15,205. There is a considerable amount of coal in Labuan now, is there not? I believe there is; it certainly has been worked for a long time, but I think not profitably. There is a later ordinance which reserves to the Crown all coals and other minerals within lands to be disposed of under that ordinance.

15,208. Then Perak? There are leases granted by the state; that is, the native government, which receives the rent of a dollar per acre, and a royalty as agreed on granting the lease, or as may be notified from time to time in the Government Gazette. There are also regulations for the alluvial mining of tin, but I have not obtained any particulars of those, for I understood they would not be required.

15,213. Natal? In Natal there is a later ordinance than the one mentioned in the notes, namely, No. 34 of 1888. The right of mining for all minerals is vested in the Crown. Mineral leases are granted for working base minerals in Crown lands, and the Commissioner of Mines may enter and bore for coal upon private lands, but the owner may grant mineral leases upon the same land, so that in that case there appears to be a double right between the Crown and the owner.

15.214. Zululand? The same as in Natal.

15,216. Then we will take Prince Edward's Island? In Prince Edward's Island there appears to be nothing, but in British Columbia on Crown lands there is a royalty of five cents per ton upon coal raised. The coal is the property of the surface owner, subject to a royalty.

15,217. Subject to royalties payable to the Crown do you mean? Yes, in regard to minerals other than coal the free miners may search for and take up claims. The claims may extend to 1,500 feet by 600 feet, and within those limits all veins and lodes belong to the miner holding the license. He has some right of following the veins outside his boundaries. He may also obtain a Crown grant covering all those minerals within the boundaries of the grant, and may run drains through unoccupied mining lands, paying compensation to the owner.

15,228. Then go to Queensland? First of all the Government has power to create mining districts; within those districts licenses are granted for mining over the Crown lands, and those licenses carry all minerals other than gold. Then licenses are also granted by the Crown over any Crown lands for 21 years, with a rent of 10s. per acre. All Crown grants reserve gold but not the other minerals. The law contains provisions preventing unauthorised mining upon private lands, and the taking of minerals upon private lands. Then there is a specific Coal Mining Law, No. 20 of 1886, under which a license is granted to occupy for one year a specified portion of Crown land up to 640 acres. Within those areas the holder of a license may search for coal. The rate is 6d. per acre. The license is renewable at the same rate of 6d. per acre for another year. A licensee, if he discovers coal, may obtain a lease for 320 acres at a rent of 6d. per acre, and a royalty, as stated in the note, of 3d. per ton of coal raised during the first ten years, and then 6d. per ton of coal raised during the remainder of the lease.

15,230. What have you to say about the note upon Victoria? In Victoria there is a very elaborate Mining Act of 1890 which is a consolidation of all their previous law. That law is later than the Act quoted in the note. There is, as in the other colonies I have mentioned, a license to search for minerals other than gold upon Crown lands. A license may also be obtained to cut races and make dams, and reservoirs, and divert waters on Crown lands, and apparently on lands leased to private persons on paying compensation. Then there are also mineral leases on Crown lands for 30 years up to an area of 640 acres with a right to cut races and make dams and reservoirs. The Governor may make regulations as to rent and royalties, I have not got the regulations, and I have not been able to trace the amount of the present royalty. There were mining leases on private property; but those appear to be only for gold, a natural distinction, as other minerals belong to the surface owner, and therefore no mining leases for them would be granted by the Government.

15,232. Now take Western Australia? Up to the present time all their regulations are approved by the Secretary of State at Home, so that they are not under a local Act as yet. Permits are granted to search for minerals. Then leases for seven years are granted of not less than 20 or more than 200 acres, and upon these Crown grants may follow for not less than 20 acres, provided plant and other machinery and improvements are erected to the value of £3 per acre. Then by the new regulation of 1890 the owners of land where minerals are reserved to the Crown may obtain a permit to mine on payment of a royalty of 6d. per ton on coal, 2s. per ounce on gold, and on other minerals 2½ per cent. on the value at the pit's mouth.

15,233. Now take New Zealand? They, again, have a very elaborate system of mining law. They have a separate law for coal mines. Leases may be granted on Crown lands, for 30 years, upon 640 acres, at a dead-rent from 1s. to 5s. per acre, and with a royalty of from 3d. to 1s. per ton, and the term may be extended from 30 years to 99 years. . . . . Then there is another law, No. 51 of 1886, in reference to other minerals. Here, as in South Australia, land which has been alienated by the Crown may be resumed for mining purposes, including land which may be required for races, dams, watercourses, and so forth. Then, of course, the owner receives full compensation, but not for the auriferous or argentiferous value of the land, and the money received by the Government is not handed over to him as in South Australia. There is a license to search within mining districts, or to search outside mining districts, and mining leases are for 21 years at 10s. per acre.

15,234. What are the regulations in Tasmania? In Tasmania mineral leases are granted for 21 years of not less than 20 acres, and for coal, shale, limestone, slate, or freestone of not more than 320 acres; of other minerals not more than 80 acres. The rent of the coal and limestone is not less than 2s. 6d. an acre, and for other minerals not less than 5s. per acre.

15,237. It seems that in three colonies in Australasia the Governments, although they have in the first instance conceded the full mineral rights to the person to whom they allotted Crown lands, have taken powers to resume those rights on certain conditions? Yes, that is the case in South Australia, New South Wales and New Zealand.

William Pritchard Morgan, M.P. for Merthyr Tydvil:

15,751. You are a member of Parliament? I am.

15,752. You have had some correspondence with the Chancellor of the Exchequer on the subject of royalties which the Crown demand upon gold mines in Wales, I believe? Yes.

15,753. The Chancellor of the Exchequer desired your letter of the 22nd May, 1890, to be sent to this Commission with a suggestion that we should examine you upon it In that letter you pointed out to the Chancellor of the Exchequer that, in your belief, the demand of a royalty by the Crown, that is to say, practically speaking, the public of England, upon gold puts the enterprise of mining for gold in this country at a disadvantage as compared with the gold mining enterprise in foreign countries? I did.

15,755. Perhaps you would explain to the Commission what are the grounds for your view that the royalty as charged in England by the Crown, the facts of which are not disputed. I presume, namely, that the terms are, at present, that if the Crown is the owner of the land the royalty is one-fifteenth of the gross produce, and if the Crown is not the owner of the land, one-thirtieth of the gross produce? Those are about the figures that they adopt now, but the figures have been varied from time to time.

15,756. What we should like to know is, what is your ground for supposing that that charge is too high as compared with similar charges in the colonies? Similar charges do not exist in the colonies. I have had interviews this week with most of the Agents General for the colonies. I find that in Tasmania no royalty is charged upon gold or any other metal; there is simply a nominal charge for what is called a miner's right. Leases of mineral lands are granted there upon the easiest possible terms. The Tasmanian Gold Mining Company, which company has paid £400,000 in dividends, had their lease renewed lately without any fine whatever, and not 1d. royalty has ever been paid by that or any other company. In that same colony the Mount Bischoff Tin Mine has paid £1,200,000 in dividends, but they have never paid a 1d. royalty to the Crown or anybody else.

15,757. Is the property in tin in Tasmania in the Crown or in the surface owner? In the Crown.

15,758. Are you certain of that? In this particular case of the Mount Bischoff it was originally a mining lease from the Crown.

15,759. A lease of tin? A mineral lease of tin. I am informed by the Agent-General that the only instance of a royalty ever having been imposed in Tasmania was upon coal, and in that case 10,000 acres were leased for five years at a peppercorn rent.

15,760. Are you aware whether the coal in general is the property of the Crown in Tasmania or the property of the surface owner? This was on Crown lands.

15,761. Then you are not speaking of private lands? No, I am speaking now of a lease having been given for coal in Tasmania for 10,000 acres for five years at a peppercorn rental. After the first five years, for 25 years at 2d. per ton for large coal and 1d. for small coal, and 1½d. for fireclay, brick-earth, lime and shale. For a further period of 30 years after the termination of the first 30 years the Government could double those royalties if they liked. In new Zealand there is no royalty whatever on gold, or any mineral or metal. The gold and silver in New Zealand are always reserved in the grants of land issued by the Crown.

15,762. Do you mean that in New Zealand anyone may work for gold or silver without paying any tax of any kind? Except the mere license fees or small rentals. In New Zealand there is now an export duty of 2s. per ounce on gold, but it is only on gold exported from New Zeland. That is by the Customs Duties Act of 1882. They have produced over £46,000,000 worth of gold in New Zealand, and they now produce about £700,000 or £800,000 per annum, and not 1d. is paid by way of royalty. In the colony of Victoria there is no royalty on gold or silver; on the contrary, they pay bonuses and rewards for new discoveries of gold and silver. Twenty years ago there was an export duty on gold of 2s. 6d. per ounce. Previously to that they used to charge them for their licenses, I think about 30s. per month; that was abolished, and this 2s. 6d. per ounce substituted for it. That, however, was found injurious to the mining interests, and that royalty was reduced to 1s. 6d.; then it was further reduced, and ultimately abolished altogether. Victoria produces between 500,000 and 600,000 ounces of gold annually. In New South Wales there is no royalty upon gold or silver, and their production is enormous. I have the Gold Fields Regulations here of all the colonies, and practically they have copied each other from time to time. The fees charged to miners for mining vary from 5s. to 10s. per annum. Then a miner's right is issued, or a consolidated miner's right may be issued to two, or four, or eight men, and those men are entitled to peg out claims upon Crown lands wherever they like as long as they do not interfere with any existing interests, and they are entitled to search for gold, and have possession of it, the law says, without any interference whatever from the Crown. In the Colony of Queensland the law is the same. There they not only allow men to work for gold and silver for nothing, but they give rewards for new discoveries. For the discovery of a gold field in Queensland, distant more than 20 miles from any place where payable gold has previously been obtained, on which there shall be employed four months after the report of the discovery not less than 200 miners, they give £500. For the discovery of gold distant more than 20 miles, and on which there shall be employed six months after the report of the discovery has been made not less than 500 miners, they give £1,000. In some of the colonies if miners have not been successful in obtaining payable gold down to a certain depth, they are given bonuses by the various Governments to assist them in sinking their shafts deeper. In England and Wales the difficulty arises particularly in this way: that the gold is invariably associated with base metals. This sample (*producing same*) is an exceedingly rich sample such as we seldom get. There you will see the gold is associated with zinc blende.

15,765. And your argument as addressed to the Chancellor of the Exchequer would be this: namely that the royalty which the public require for the working of gold in this country places the producer of gold here at a disadvantage as compared with the producer of gold in the Australian colonies and thereby tends to check the enterprise? It has practically stifled the enterprise because 447 licenses have been already granted by the Crown to persons desirous of working for gold in Wales and only one has taken advantage of it, and we have been obliged to take advantage of it because we had expended so large a sum of money.

15,770. Do you propose that the public should charge no royalty on the gold worked in this country? No, on the contrary I am strongly in favor of the Crown insisting on a royalty and maintaining control of the industry.

15,771. Then what royalty would you consider to be a fair royalty from your point of view as compared with the licenses and so on given in the Australian colonies? The licenses in the Australian colonies are so nominal that I could not make any comparison, but I do not think that the gold mining industry of Wales can carry more than a handicap of 2 per cent. on the gross product.

15,772. Would you propose a royalty of 2 per cent. on the gross product? I do not think that that would kill the industry; it would sufficiently handicap it, and it would be in my opinion a source of immense revenue to the Crown.

Gold and silver are the only minerals reserved for the Crown on freehold lands, and mines containing ores of these metals may be worked under a royalty. But there are no valuable mines of these ores in the United Kingdom; the most productive are in Wales, where the amount of royalty received for gold in the fifty-five years 1836-91 was only £6,364.

The Ecclesiastical Commissioners in England have the control over minerals in the lands of the state church. They are probably the largest owners of minerals in England, and their total income from royalties, way-leaves and other profits is £300,000 a year. Minerals in the Crown forests are also worked under leases, subject to royalties payable to the state treasury, and the total revenue derived by the Crown in the year ended 31st March, 1891, was £51,599. This included royalties on coal, iron, lead, zinc blende, slates stone, gold, silver, copper, tin, salt, etc.

But on all private lands the minerals go with the freehold, saving that on a sale of land "any earth, coal, stone or mineral may be excepted, and any rights or privileges may be reserved."

The general practice, as will be seen in the evidence taken by the Commissioners, is for the owner of the freehold to lease a mining privilege upon his property subject to payment of a fixed rent and a royalty, and usually to such terms of working as he may see fit to exact.

It is obvious that there are many grievances under this system, and among representatives of labor bodies the opinion prevails that private property in ores and minerals ought to be confiscated by the state. But the representatives of other classes, almost without exception, hesitate to approve a policy for the nationalization of minerals, or if they do it is on the condition of compensation.

It is certain that dissatisfaction with the system is widespread, and it is quite likely that were British mining companies and miners to begin in a new country they would favor some alterations, if not an entirely new policy. Hon. Mr. Abigail testifies very confidently in favor of government control of mineral lands as against the levying of royalty by private owners in New South Wales. Dr. Raymond, on the other hand, has confidence in the policy of private ownership; but he does not make it clear that reservation of minerals and provision for a light royalty payable to the public treasury would not have given as great results in the United States. What he does make clear is, that the coal and iron mines pay enormous tribute to private owners; and that, as in the case of the Reading Railway Company, the payment of vast sums to private owners for mineral rights is a boon to a few at the risk of disaster to many.

The sliding scale, intended to raise or lower the royalty dues according to the market prices of minerals, is regarded in England with favor, and in a number of instances it has been adopted; but it is opposed by some because it might necessitate an examination of the books of mining companies. In practice, however, this objection does not appear to arise, as by the terms of lease the royalty bears a fixed proportion to the selling price of the product.

In the Ontario Act this principle of a sliding scale is provided for in two ways, first by the clause which makes royalty a percentage of the value of the mineral at the pit's mouth, the amount of it thus rising or falling with that value, and secondly by the clause which enables the Government to make the rate by Order in Council up to a fixed maximum.

The rates of royalties in Great Britain differ very greatly, being dependent upon the situation of a mine, its shipping facilities, and the character of the mineral; but the range is from one-fifth to one-eighteenth of the market value.

There can be no question that in most cases the system of paying royalties to private owners is an advantageous one to these parties. They have no risks, and whether the mines are worked or not, or whether mining companies make a profit or not, the owners are sure of their rent and almost invariably of a minimum fixed sum for royalty besides. Naturally enough they would prefer activity in mining operations and substantial profit for the companies, since their own revenue is in a large degree dependent thereon; but one will look in vain through the evidence for an indication that the owner of a mineral property would willingly surrender any of the advantages he possesses as lord of the land.

The total amount paid in rents and royalties to private owners of mineral lands in Great Britain upon the production of 1890 is estimated to be not less than £6,500,000, or say $32,500,000, a sum larger than the yearly revenue of the Dominion of Canada from customs and excise taxes.

THE ROYALTIES A QUESTION OF PUBLIC INTEREST.

The question of Crown royalties has clearly another side, and I feel bound to say that I am not now as confident as when I wrote the Section which treats of this subject in the Report of the Commission on the Mineral Resources of Ontario.

No one who reads the Reports of the British Commission on Mining Royalties will pretend to say that the system of private royalties is free from grave objections, and where the minerals go with the surface to the owner of the fee it is almost inevitable that private royalties will be levied. It is so in Great Britain and the United States, as has been shown. In Ontario we are hardly old enough to have an experience; but the system is being introduced here also.

If therefore the minerals can bear a royalty payable to the owner of private land, there is no obvious reason why they cannot bear it if payable to the public treasury, and more especially when the lands are held by the miner or mining company in fee or leasehold direct from the Crown at the low rates fixed by the Mining Act.

The objection to mining royalties certainly loses much of its force when we come to look upon them in the light expressed by Hon. Mr. Abigail, in his evidence before the British Commission, as simply "a small equivalent to the Crown for great benefits granted to private people." And furthermore there is the point of view from which so cautious a man as Sir Isaac Lowthian Bell regards the royalties when in speaking of the mining policy of Spain he says: "If I were at the head of the Spanish government and I saw foreigners coming in and reaping very large sums of money from mining enterprises there, I should begin to enquire whether a reasonable portion of it should not go into the national exchequer." If to "foreigners" we add "speculators" or "private people," is the sentiment less reasonable or just in the public eye?

Is it in the public interest, or in the interest of the mining industry, that foreigners, citizens, or private people of any class should be encouraged to secure blocks of mineral land from the Crown and hold them until they can be sold at a great advance on the cost price, or lease them at a fixed rental and upon a royalty, or perhaps sell at a good figure and retain a royalty interest besides? Or is it not more desirable that the miner should deal directly with the Government and purchase or lease the land at a low fixed rate subject to a moderate royalty ? *

It will be said that under the latter system the speculator can still operate, since h may take up the land as before and dispose of it on the best terms he can get. This n doubt will happen ; but mining companies are not disposed to pay double royalties wher by dealing directly with the Crown they can obtain lands on more liberal terms, withou any middleman to levy tribute upon them.

In so far as prospectors are concerned, they have done a valuable work in th country, as without their service many ranges and deposits of minerals would have remained undiscovered. There is still a large area to be explored in the northern districts and as it is now well established that this is a mineral-bearing country it is not unreasonable to expect that capitalists and mining companies will employ prospectors to explor it in their interest. Or possibly some satisfactory way of compensating them might b found such as obtains in the Australian colonies, where rewards are offered by the Government for the discovery of ore or mineral in new districts.

The Government has a right to look to the public lands as a source of revenue, bu it cannot afford to make the mistake of putting on such prices, or rents, or royalties a would be a burden upon industry. The interests of the Government and the minin companies must be interdependent, and in the two new features of the amended Ac which provide for the leasing of mineral lands and the levying of a royalty a bond o connection is maintained. When the lands are sold outright the interest of the Government ceases ; but where they continue to be a source of public revenue the occupier have a reasonable claim for aid in the construction of roads and railways, so necessary to successful mining enterprise in our rough northern woodlands.

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* These and other features of the mining question are dealt with very forcibly in the following lette from Mr. C. S. Morris, of Toronto, written to me under date of December 21, 1891 : "Referring to th subject of the development of the mineral resources of Ontario, I beg to express the opinion, based on considerable knowledge and experience, that as to the commercial minerals the want of markets is a suff cient and constant reason for non-development, while as to the precious metals the backward condition i very largely owing to the disinclination or inability of owners of mining claims to test and prove the valu of their properties before offering them for negotiation. It may as well be thoroughly understood an realised—and the sooner and more widely the better—that foreign investors and speculators, both in th States and in the old country, have no use for untested and undeveloped mining properties, and will no invest in such, saving in very exceptional cases, at any price whatever. The foreign speculative centre are constantly overstocked with mining properties of all kinds, in all stages of development, and it is onl those which are well proven and vouched for that stand much chance of attracting the favorable considera tion of investors, and so obtaining the capital necessary for their full development and operation as mines A second cause, I may suggest, is the non-existence in this country of a class of practical mining investor —men who know enough of mining to invest their own capital in the industry and make it a permanen pursuit and look for their profits out of the actual operation of the mines, and in so doing also prove th value and create confidence abroad in the wealth of our mineral deposits. We go abroad and assert tha the country possesses this wealth, but we do not sufficiently demonstrate it by showing the actual output It is a matter of too much bragging and too little work. Our "alleged" mining men are, with few excep tions, simply speculators in wild lands. It may be said that there is no home capital available for actua mining investment, but I am quite sure that there is in this country, in the aggregate, a large amount c speculative capital which is frequently employed in quite as risky ventures as mining, and which might b attracted thereto if properly approached and its confidence gained. But too many holders of mining clai pursue an unintelligent and somewhat dog-in-the-manger policy, and will not work and develop the proper ties themselves nor permit others to do so on any reasonable terms. And this leads me to mention anothe evil, and that is the ridiculously exaggerated notions of *price*, so entirely disproportioned to *value*, entertaine by the large majority of owners, especially those residing at the different mining localities, whose ideas an knowledge are purely local and therefore narrow. But this matter of exaggeration seems to be incidenta to new mining regions everywhere and generally cures itself in time, when the first set of owners are eithe dead or starved out. I regard the growth of a home interest in actual mining and the adoption of it as legitimate business as an object to be especially aimed at in any efforts to better the situation, and perhap this may be considerably aided by the amending of the Ontario Joint Stock Act so as to permit of th formation of mining companies in a much more simple, inexpensive and expeditious manner than can b done at present. Actual and extensive mining operations are generally too heavy for a single individua so that a combination becomes necessary, and to effect this a limited liability company must be forme To do this the present Act is too slow, cumbrous and expensive. It should be as easy to form and inco porate a mining company in Ontario as in England or in many of the United States, as for instance, Min nesota, Illinois, New Jersey, West Virginia, etc., where a single day's time and a few dollars of expens are all that is involved in obtaining a charter for a company. The English Companies Act is stringent i its provisions, and at the same time simple, easy and expeditious to form and operate under, and such facili ties would be no more liable to abuse in Ontario than in England."

ARTESIAN WELLS.

In nothing is the untiring activity of nature better shown than in the never-ending round of processes which go to maintain and distribute the water supply of the globe. Moisture descends upon the surface of the earth in the form of rain and snow. Part falling upon mountain sides and untimbered spaces may run at once into streams and rivers, part descending upon forest lands may be detained upon its return journey by a slower process of percolation, part falling upon pervious soils may sink out of sight to re-appear as springs or to form those underground supplies of water which are the sources of artesian wells, and part may remain for long years locked up in arctic and antarctic regions in the shape of glaciers and vast fields of snow; but, speaking broadly, the moment water is deposited from the clouds it at once begins a voyage to the ocean. There, and on subsidiary sheets of water, evaporation is continually setting it free again and giving it to the clouds, which re-deposit it on the land, once more by direct or tedious route to seek its way to the sea. By this beneficent circle of operations the equilibrium of water on the earth's surface is maintained. The sea is never full, and the earth is never dry.

But although this is the case viewing the earth as a whole, there are nevertheless parts of its surface where rain either never falls at all or falls in such scanty volume as to be inadequate to the needs of man.

Fortunately for the people of Ontario, there are no portions of this extensive province which are rendered useless by the lack of rain. Over by far the greater part of its occupied area the labors of the farmer in the tilling of his soil are rendered effective by the falling of the rain in due season, and in most localities he is, in ordinary years, at no loss to procure ample supplies of good water. Where a spring is not found issuing from the ground in a convenient spot, a well sunk a few feet in the upper stratum of the soil generally secures an adequate supply.

There are sections of the province however where it is difficult to obtain from the surface good water in large enough quantities to answer all the purposes of farm and domestic use, as where the drift is composed of impermeable clay. There are other sections, as in the eastern counties, where the rock lies near the surface and acts like a system of natural underdrainage, so that the water absorbed by the earth from precipitation is quickly carried away by springs or in streams.

In towns and cities, again, the conditions of life are altered. Even if an abundance of water may be had by sinking wells, it is apt to be polluted by sewage and surface drainage, and its use is attended with danger to health and life. An abundant supply of water is required for protection against fire, and even if a river may be taken advantage of for this purpose its waters are frequently found to be contaminated by the drainage of the country through which it passes to such an extent as to be unfit for domestic use.

Even those cities which are situated on the shores of the great lakes, and therefore on the brink of an inexhaustible supply of pure water, find that within the area affected by the city sewage the pollution is so great as to cause them to consider very seriously the question of obtaining their supplies from some other source.

In such circumstances as these the question of artesian wells becomes of great importance.

In countries where the rainfall is insufficient for the requirements of agriculture artesian waters are resorted to for purposes of irrigation, often with extraordinary results, In some parts of the desert of Sahara, for instance, whose very name is a synonym of aridity, the enterprise of French engineers has of late years wrought a remarkable transformation. Many artesian wells have been put down which supply the requisite moisture for the cultivation of the date-palm and other forms of vegetation, and which have become the centres of fertile oases whose freshness and verdure afford welcome relief from the dry and sandy monotony of the surrounding desert. It is stated that upwards of 600 borings have been made within the limits of the great desert, and the transforming effects of artesian water among the sandhills of Algeria are said to be equally great.

The whole question of irrigation is receiving great attention in the United States, where large areas in the western states, otherwise fertile and capable of sustaining a large population, are made useless by the want of sufficient water. Artesian wells are found of great advantage in remedying this defect, and an investigation recently undertaken by the Department of Agriculture shows that thousands of such wells have been sunk and many districts of considerable extent have already been reclaimed. The work of reclamation is actively going on, and many sections hitherto uninhabitable are being opened to the fruit-grower and the farmer.

In the pastoral districts of Australia the question of obtaining a supply of drinking water for stock during the dry season is often a very serious one, and it is also necessary to have watering-places at intervals along the routes over which stock is driven to market, and which are almost impassable in a drought. Resort has been had to artesian borings for the purpose of providing such watering-places, with considerable success. The government of New South Wales is now engaged in putting down artesian wells on an extensive and systematic scale, with the double object of watering certain arid stock routes and of testing the geological formation of a large area of hitherto unexploited country.

No necessity however has as yet been felt in Ontario for the irrigation of crops or for public watering-places for stock, and the climatic and agricultural conditions of the province are such as to make it unlikely that we shall ever require to attempt the utilization of artesian waters for either of these objects.

It is for the purpose of supplying water for farm and domestic use, and for meeting the demands of cities, towns and villages for private, manufacturing and fire protection purposes, that artesian wells are of importance in this province, and their importance in these respects is likely to increase rather than diminish in the future.

It is no doubt true that a source of supply of public water for towns and villages, not inferior in importance to that afforded by artesian wells, is to be found in springs which abound in many parts of the province.

The towns of Owen Sound and Milton and the cities of Guelph and London find in neighboring springs an abundant supply for all purposes, and where perennial springs of sufficient size are found conveniently situated it is doubtless the part of wisdom to utilize these in preference to taking the risks inseparable from the sinking of wells in search of artesian waters. The quality of the water supplied by springs is usually good, and the expense of providing a system of waterworks is not necessarily any greater in one case than in the other.

Apart however from the fact that springs are frequently natural artesian wells, their presence is always sufficiently obvious, and a little experiment and calculation is all that is required to ascertain whether or not they are likely to prove equal to the demand proposed to be made upon them.

It is not therefore the purpose here to treat largely of springs, but to seek to convey what information is available regarding those more hidden reservoirs of water whose underground existence may often be unsuspected in circumstances which would render a knowledge of them in the highest degree beneficial.

CONDITIONS OF ARTESIAN SUPPLY.

The conditions necessary to the presence of underground water which may be brought to the surface by means of artesian wells are now sufficiently well understood. It is a matter of much greater difficulty however to say whether or not a flowing well is likely to be found at any particular spot.

The requisite conditions are that the edge of an inclined stratum should be exposed to the surface at a level higher than that of the proposed well, and that this water-bearing bed should be confined both above and below by impervious strata. It is of course essential that the water in this stratum should have no means of escape at a lower level, otherwise, no matter how elevated the fountain-head or how copious the rainfall may be, no considerable pressure can be exerted in an upward direction at any point in the descending stream.

The typical requirements are met if the water-bearing and associated strata come to or approach the surface in such a way as to form a basin or depression in the region of the proposed well. It is not however absolutely necessary that such a basin should exist. A similar effect will be produced if by a change in the composition of a descending water-carrying stratum the passage of the water be rendered difficult or impossible, as for instance when a coarse, open sandstone passes into a fine-grained compact rock. In such a case it is evident that the water will descend until its progress is checked by the impermeable part of the bed and will there remain under as great pressure as if the stratum occupied a basin-shaped depression.

Strata of sand, sandstone and gravel, which afford free passage to water, are usually those in which the desired supply is found, though occasionally even limestone rocks, much broken and fissured, are found available as sources of artesian wells. In the latter case however the irregular and tortuous courses which the underground waters must pursue as they flow along the joints and fissures of the rock and through the channels worn in its soluble portions make the task of locating a well entirely a matter of chance. The confining beds are usually of clay, and in most cases, if of sufficient thickness, they act as almost perfect barriers to the passage of the water.

It is as important that the bed above the water-bearing stratum should be impervious as the one below. The tendency of water is of course to obey the law of gravitation and sink deeper and deeper into the earth, and were its downward course unobstructed it would probably descend until that great depth is reached at which the tension of superheated steam is equal to the hydrostatic pressure. On the other hand, if the stratum superimposed upon the water-bearing bed be of a permeable character the water will rise in it up to the permanent water level, and make its escape as springs where erosion has brought the surface down to this level.

It is obvious that the quantity of water to be found in a given permeable stratum will depend upon (1) the rainfall, and (2) the area of such stratum laid bare at the surface.

The quantity of rainfall varies in Ontario from year to year, but this variation is within moderate limits, and the average is probably not far from thirty inches a year. At this rate the annual precipitation upon an acre would be about 680,000 imperial gallons. If one-half of this quantity sank into the ground, for every acre comprised in the gathering-area the water-bearing stratum would receive 340,000 gallons a year, or rather less than 1,000 gallons a day.

Of course such figures are only approximate, and the whole quantity of water contained in the stratum would not be tributary to any one well, but if the area of the district forming the collecting-ground for artesian water in any particular case were once ascertained, it would not be difficult to arrive at an estimate of the quantity of water contained in the stratum, though the actually available supply would in all cases be considerably less.

The limit of the yield must necessarily be much within the limit of the receipt of water, and this fact should not be lost sight of in any calculations as to the number of wells which may profitably be sunk within a given area, or the quantity of water which they may be expected to produce.

Experience in some parts of the United States has shown that the supply of artesian water is no more unlimited in any given field than a supply of petroleum or natural gas, and though not productive of utter exhaustion as in the case of the latter, a multiplication of wells beyond the resources of the underground supplies has the effect of diminishing the flow of water at each well and correspondingly lessening its value and usefulness.

It has also been observed that the great number of wells sunk in and around London, England, has reduced the flow to such an extent that wells which were flowing a few years ago have now to be pumped.

The area of the gathering ground will be determined by the thickness of the stratum and the angle of its dip at the place of exposure. If the angle of the outcrop be high and the bed thin, the area exposed will be small and the supply of water probably insufficient for large and important wells. If the angle be low and the bed thick, a more extensive area will be laid bare and the quantity of rainfall received will be correspondingly increased.

The height to which the water will rise in the well, or above the surface of the ground, will theoretically be the height of the collecting area above the site of the well, or, speaking more accurately, the height of the permanent water level in that area. In practice however it will not rise so high.

The pressure under which the water travels from source of supply to point of delivery is diminished by several causes. Chief among them are the leakage which takes place when the confining beds are not entirely water-proof and so permit a portion of the water to be absorbed and transmitted through them, and the friction to which the water is subjected in its underground passage, varying according to the composition of the stratum through which it flows. Sand and gravel offer the minimum amount of opposition to the flow of water, while in close-textured rock the friction reaches a maximum.

The conditions in which artesian wells may occur are so varied that any definite rule as to the amount of loss by friction may be misleading when applied to particular cases, but in general it has been found that a deduction of one foot should be made from the height for every mile between the collecting area and the site of the well.

SURFACE GEOLOGY OF ONTARIO.

The geological conditions of a country have of course a very important bearing upon its water supply, and a brief sketch of the superficial geology of Ontario may help to a better elucidation of the subject in hand.

The palæozoic rocks which underlie the southern and western portions of Ontario are separated from the post-tertiary formations resting upon them by long ages of geologic time. The newest member of the palæozoic series is the Devonian, which in other parts of the world is followed by the Carboniferous, Permian, Triassic, Cretaceous and Tertiary systems. Whether the corresponding rocks were deposited upon the surface of the older groups and afterwards ground off by slow erosion or swept away by denuding agencies, or whether, as some conjecture, the surface of what is now Ontario may have been dry land affording no opportunity for the deposition of higher strata, it is impossible now to tell. Certain it is that if these missing members in the geological scale ever existed, they were effectually planed away before the era set in which finally left the surface of this part of the continent in the shape in which it now is.

It is to the operations of the glacial age that the existing contour and physical conditions of Ontario are due. The vast masses of ice which flowed in rigid, irresistible streams from the cold northern regions towards the south-east and south-west plowed up the surface of the older rocks, softened and decomposed as it is supposed to have been, and ground the fragments into the clays, sands and gravels which were deposited in the beds of the glaciers or in the lakes formed by the melting of the ice under the heat of a succeeding warmer era.

A submergence of the land probably followed the glacial period, in which the material accumulated during the ice age was to some extent worked over, and the present arrangement of the superficial deposits effected.

The lowest deposit is the boulder-clay or till, which is followed by various strata of clay, sand and gravel. Of these strata the Erie and Saugeen clays, the Algoma sand and the Artemèsia gravel are sufficiently continuous and recognisable to be granted definite places in the scale.

The Erie clay, which is of a blue color, with thin gray bands, underlies the whole of the south-western part of the province, and is found as far as Brockville on the east. Resting unconformably upon this in many places is a thinly bedded, brown, calcareous clay, known as the Saugeen clay, so called from an extensive exposure in the valley of the Saugeen river.

The Erie clay has nowhere a depth of more than two hundred feet, though it occurs at levels showing an extreme difference of about five hundred feet.

The Saugeen clay is probably rather less in thickness than the Erie clay, but is found overlying that formation in its higher as well as in its lower levels.

Beds of sand and gravel in many places separate the Erie and Saugeen clays, and are of frequent occurrence in the latter. Under otherwise favorable conditions these beds may often be found acting as reservoirs for the supply of artesian waters.

In the district lying north of lake Huron and between the Georgian bay and the Ottawa river, where the rock is not protruded at the surface it is generally covered by a yellowish sand resting in broken areas immediately upon the Saugeen clay. This sandy formation, which supports—or rather did in the past support, for the lumberman's axe and the forest fires have done their work too well—great groves of noble pine, is called the Algoma sand.

The Artemesia gravel is a belt of loose gravel extending parallel to the Niagara escarpment from Owen Sound to Brantford, following the highest ground of the peninsula. The Oak Ridge may be considered a spur of this remarkable belt, running in a north-easterly direction and rising at a point north of Toronto to a height of 720 feet above lake Ontario.

In addition to the strata thus briefly enumerated are many deposits of sand and clay overlying them which are too irregular and local in their character to admit of classification. Crossing these strata in almost every direction are streams emptying their waters into one or other of the great lakes or the St. Lawrence or Ottawa river, which have worn their way down to their present beds, in some instances through many feet of sand, gravel and rock.

It is evident that although we have not here those foldings and upliftings of tertiary and secondary formations which go to form artesian basins on the grandest scale, the conditions are nevertheless eminently favorable for the existence of smaller depressions, local in their character, but capable of yielding large supplies of water.

It is accordingly found that in almost every part of the southern and western portions of the province, in other words, in those districts where the superficial deposits, generally speaking, are deepest and most varied in their nature and order, artesian water is obtainable at no great depth.

Large supplies of water are also frequently found in the underlying rock, as in the case of wells bored for salt and petroleum, the southerly dip which characterises the older formations as well as the chief members of the post-glacial group being sufficient to afford the necessary pressure upon the contained water.

The water found in the rock is usually more or less mineralized. Sulphur and magnesia are frequently present, and nearly all the deep wells of south-western Ontario yield salt in greater or less quantity. Many of them also give traces of oil.

The valleys of the rivers and streams doubtless expose permeable strata which must receive a portion of the rainfall, and where they are of a sandy or gravelly nature and confined above and below by beds of clay they present the conditions which require only the existence of sufficient pressure to constitute them the sources of artesian wells.

Where a dip occurs in the strata followed by an upward inclination the requisite pressure is provided, and a boring down to the water-bearing bed is certain to be rewarded by a supply of water. The gathering grounds provided in the immediate valleys of rivers must of necessity however be of limited area, as the outcropping of the permeable strata will in all ordinary cases present too high an angle to permit of a large section being laid bare.

In the uplands lying between lakes Huron and Erie and Ontario, and north of the last mentioned lake, are areas extensive enough to collect rainfall for the supply of large reservoirs of artesian water.

A synclinal basin extending from London westward to the river St. Clair is composed of beds of sand and gravel confined between impermeable clay strata, and readily yields artesian water at depths varying according to the dip of the strata and the undulations of the surface.

Similar basins occur in various parts of the province. An interesting example is afforded at Sundridge, in the district of Parry Sound, where a depression apparently exists on the surface of the Laurentian rocks filled in by post-glacial deposits. Here several wells have been sunk from 80 to 100 feet deep, and water obtained rising three or four feet above the level of the ground.

QUALITY OF ARTESIAN WATERS.

Artesian waters vary greatly in quality, even in wells comparatively short distances apart. In some wells the water will be of great clearness and purity, while in others, perhaps at no great distance, it will be charged with mineral substances of various kinds to such a degree as to be unsuitable for domestic or manufacturing purposes.

The reasons for such variations are obvious.

When water descends from the clouds it is usually of a high degree of purity, containing merely such foreign ingredients as it may come in contact with while on its downward way through the air. Should it fall upon the upturned edge of an open sandy stratum of low inclination, which maintains a uniform texture throughout, the water will meet with little or nothing in the way of mineral substances which it can dissolve and carry away, and hence if brought directly to the surface by means of an artesian well it may be found to be quite soft and pure. On the other hand, if the receiving bed be of a calcareous nature, or if the water in its underground passage force its way through the pores of strata retaining a large proportion of their original salts, it will inevitably become hard and more or less mineralized.

The degree of mineralization depends also to some extent upon the depth to which the water penetrates and the length of time it remains beneath the surface.

The temperature of the earth increasing by one degree for every 50 or 60 feet in depth, the water will become warmer in like proportion, and its capacity to dissolve and hold in solution minerals with which it comes in contact will be correspondingly heightened. The longer it is retained in the underlying strata the greater will be its opportunity for exercising these solvent powers. Consequently if raised at once from a considerable depth, as in an artesian well, the chances are that such water will be both warmer and more highly mineralized than if drawn from a stratum nearer the surface.

This general rule is borne out by the results of artesian borings in various sections of Ontario, the water from shallow wells being more frequently fresh and potable, while that obtained from the rock or at great depths is often unfit for use on account of the minerals held in solution.

There are however many exceptions to the rule. It does not follow because a flowing well is obtained at no great depth that the water has travelled but a short distance from its source, or that the stratum through which it has passed may not at some point lie much deeper. If such is the case, the water from a shallow well may be mineralized to a greater or less degree.

On the other hand good water may be procured at great depth if the bed in which it is found has a high inclination, or if it is composed of insoluble sand or other material closely confined by impermeable strata.

The irregularity of the surface deposits of Ontario, as already pointed out, and the variety of ways in which they overlap each other, increase the chances of striking water at an easy depth, but cause as well abrupt and great variations in the depth at which water is present.

NATURAL SPRINGS AS SOURCES OF SUPPLY.

When a town has advanced to that stage of progress at which ordinary wells are felt to be no longer safe and convenient, and when the need of fire protection presses itself upon the minds of the inhabitants, it is to springs that attention is first directed as being one of the most apparent and directly available sources of water supply. Many of our villages and towns are fortunate enough to be so situated as to be able to take advantage of springs, and some of them have already done so. Before giving particulars regarding artesian wells in various parts of the province, it may not be out of place to cite a few cases in which springs are made use of with excellent results.

City of London.

The city of London is abundantly supplied with water of first-class quality from springs situated along the bank of the river Thames, some three miles below the city. These springs issue from the hillside on the surface of a stratum of "hard-pan," and the quantity of water available has been very largely increased by running a gallery along this stratum for about half a mile. The water is then conducted to the pumping basin, from which it is distributed through the city mains.

The sources of the springs are on the higher grounds to the south, which rise to a height of nearly 200 feet and are formed largely of pervious sands and gravels.

Town of Milton.

From the "mountain" or isolated elevation of limestone rock which rises at the distance of about a mile from the town of Milton flow three natural springs at a height of 300 feet above the level of the town. These springs unitedly supply about 35 gallons a minute, the water being collected first in large cisterns and thence conveyed through a four-inch pipe to the reservoir a distance of about 300 yards.

The water is of good quality, not hard, and is extensively used for domestic and other purposes, no new wells being now sunk in the town.

The waterworks system also affords efficient protection from fire, and Mr. T. G. Matheson, county crown attorney, who furnishes these particulars, states that the insurance rating of Milton has in consequence been raised from class "E" to class "D."

Town of Owen Sound.

Mr. James C. Kennedy, town engineer, furnishes the following facts respecting the water supply of Owen Sound.

The town is supplied from springs which rise from the hillside at a height of about 200 feet above the level of Georgian bay, or say 180 feet above the level of the main street in the centre of the town. Their volume is about 400 or 500 imperial gallons per minute in dry seasons of the year, and from 900 to 1,000 gallons during wet or freshet seasons. The average flow throughout the year is perhaps 600 gallons a minute; but by taking in other springs in the vicinity the supply might be largely increased.

At the minimum flow of 400 gallons per minute the daily capacity of the springs is 576,000 gallons, and at the maximum of 1,000 gallons per minute it is 1,440,000 gallons.

The daily consumption of the town in winter is 200,000 gallons, and in summer probably 300,000 gallons. The water is of good quality and is largely used for domestic and fire protection purposes.

The reservoir, which is three miles distant from the springs, has a capacity of 500,000 gallons and is situated 180 feet above the level of the lake.

ARTESIAN WELLS FOR TOWN SUPPLY.

Where springs are not available on account of their absence or insufficiency of volume the choice in the case of towns removed from the banks of the great lakes may sometimes lie between utilizing the waters of a stream or river and boring for artesian wells. In few cases will river water be found to possess the requisite purity, and if the topographical conditions are such as to lead to a belief in the existence of artesian water the money spent in an endeavor to reach it will generally prove a profitable investment. The towns of Goderich, Essex (formerly Essex Centre), Chatham, Newmarket and Barrie, among others, afford good examples of the utilization of artesian wells in supplying water for public use.

TOWN OF GODERICH.

The inhabitants of the town of Goderich were in the position of being able to make choice of two sources of public water supply, either of which in countries less abundantly supplied with good water than Ontario would be considered an inestimable boon. At their feet lay lake Huron, whose waters cannot yet be appreciably lessened in purity by the population on its borders, while beneath them borings in the salt formation had proven the existence in the upper limestone layers of artesian waters of great volume and excellence.

It was decided to make use of the latter, and six wells were sunk on the edge of the lake about ten feet above the water level, two being put down to a depth of 263 feet and four to a depth of 240 feet.

The water rises about twelve feet above the surface of the ground or about twenty-two feet above the level of the lake, and the supply appears to be inexhaustible. The consumption of the town rises as high as 450,000 gallons a day.

The Holly or force-pump system of water-works is in use and ten miles of mains have been laid, the total cost of system and mains having been about $75,000.

An analysis of the water shows it to be soft and of great organic purity and excellent quality. It is almost entirely free from chlorine, showing that it has no connection with the salt beds below which are of much greater depth.

TOWN OF ESSEX.

At Essex the want of a sufficient supply of good water was long felt to be a serious disadvantage. In the fall of 1890 a by-law was passed appropriating the sum of $26,500 for the purpose of sinking artesian wells.

In the summer of 1891 borings were made which proved the existence of good water at a depth of about 125 feet. Three wells were sunk in proximity, the strata penetrated being given by Mr. John Milne, mayor, as follows: Clay, with occasional sand veins, 100 feet, hard-pan one or two feet, then a bed of gravel where there was a good supply of water, after which the rock was struck and penetrated about 18 feet. Here a good flow of water was found which rose to within 27 feet of the surface. Around these three wells a reservoir 25 feet wide and 50 feet deep was excavated into which the water flowed. This was built up with brick and cement and cemented thoroughly at the bottom.

From the reservoir the water is pumped to an elevated tank which furnishes sufficient pressure to destribute it through the mains and to throw a stream over any building in case of fire.

The quality of the water is excellent, and the supply is estimated to be sufficient for the wants of the town.

The cost of sinking the wells and constructing the whole system of water-works did not exceed the sum voted for the purpose.

TOWN OF CHATHAM.

Greater difficulties had to be overcome at Chatham. A company undertook the contract of supplying the town with artesian water and made a number of borings within the limits of the town itself. At a depth of 64 feet they struck the rock, lying immediately upon which was a layer of coarse gravel about three inches in thickness. Above this lay 2½ feet of very fine sand. In these strata a good supply of water was obtained, but on putting a steam pump at work on one of the wells the fine sand or silt was soon found to fill the pipe and stop the flow of water. None of the devices which were resorted to had the effect of checking this inflow of silt and the wells had to be abandoned.

It was then proposed to secure a supply of water from the river Thames on which Chatham is situated. The agreement between the town and the company prevented resort to a source so questionable in point of purity, and a new field of operations was found in the township of Raleigh, some four miles south of Chatham, where artesian wells bringing the water just to the surface had been known to exist for years.

A number of borings revealed the fact that a large supply of good water could be obtained at a depth very little exceeding that at which water was found at Chatham, and in a sand bed much coarser in character than that encountered at the town.

On the farm of Mr. Laurie a well four feet in diameter was dug to a depth of 32 feet, and bricked up to a height of two feet above the surface. From the bottom of the well an iron casing 13 inches in diameter was sunk to the rock, 40 feet further down. A bed of sand between two and three feet thick lay between the rock and an overlying stratum of clay, and supplied a column of water rising to the surface, which on pumpng is not reduced to a lower level than 17 feet from the ground.

At a short distance away a reservoir 36 feet deep was sunk and connected with the supplying well by a pipe 30 feet below the surface. A pumping station was built, mains laid to the town and a system of water-works successfully inaugurated early this year (1892). The daily consumption of water does not as yet exceed 150,000 gallons, wells being plentiful in the town. The works are capable of supplying 1,000,000 gallons daily at least.

That the water-bearing stratum in Raleigh thins out in places has been shown by the fact that in several borings made close to productive wells the clay bed was found to extend to the rock. Such cases of course constituted "dry holes" where no water was found.

Following is the average of several analyses made of the water :

Free Ammonia, per million parts	.3600
Albuminoid Ammonia	.0900
Chlorine	202.0000
Oxygen absorbed in 4 hours	.6457
Oxygen absorbed in 15 minutes	.5430
Nitrogen	.1130
Hardness	6.5000

TOWN OF LEAMINGTON.

At Leamington in the county of Essex, near the lake shore, an artesian well for the supply of public water discharges a stream five feet above the surface of about 50 gallons per minute. The depth of the well is 55 feet. The following analysis of the water from this well may be compared with that of the Chatham water :

Chlorine, per million parts	1.500
Free ammonia	.130
Albuminoid ammonia	.040
Nitrates	Traces.
Oxygen absorbed in 15 minutes	.156
Oxygen absorbed in 4 hours	.300
Total solids	322.000
Phosphates	None.
Hardness	10.360

TOWN OF NEWMARKET.

At Newmarket, which is situated on the northern slope of the Oak Ridge, the wells which furnish the town supply are four in number, all sunk within a few feet of each other. Their dimensions and depths are as follows: 4½ inches diameter, 145 feet; 3½ inches diameter, 160 feet; 6 inches diameter, 147 feet; 6 inches diameter, 250 feet. They are all flowing wells and discharge their contents into a cement reservoir from which the water is pumped into the mains and an upper reservoir.

The natural flow is greatly augmented by pumping. The water is pure, clear and cold, and is largely used.

The stratum in which the water supply is found is composed of gravel, and is reached after passing through a bed of blue clay 100 feet in thickness. Water is also found at a depth of 40 feet, but in smaller quantity, and is utilized in a few wells by private families.

TOWN OF BARRIE.

Good supplies of artesian water are found and made use of for public purposes at Barrie, in the county of Simcoe. Mr. Henry Bird, town clerk, furnishes the following particulars:

The number of borings is 16 or 17, of which 13 or 14 have been successful and are still flowing, although the flow has diminished in some of them.

.Beds of sand and clay of about equal thickness are penetrated, the clay varying in color and consistency, some of it composed largely of minute shells.

The wells vary in depth from 100 to 140 feet, the average being about 120 feet, and are from 2½ to 4 inches in diameter. The capacity of the 4-inch wells is about 150 gallons per minute, the public supply being drawn from two wells of this class. The water is good and moderately soft.

All are flowing wells, some rising to a height of ten feet above the surface.

TOWN OF MIDLAND.

At Midland, on the Georgian bay, borings were made by a hotel proprietor which R. McGee, M.D., states are of a depth of 35 feet and penetrate the following strata:

Soft sandy soil 20 feet, hard pan 3 inches, sandy soil 15 feet. A hard gravel bed is then reached in which an abundant supply of flowing water is found.

Each of the wells yields at the rate of 24 gallons per minute, and the quantity appears to be gradually increasing. The water is suitable for use and is utilized in the hotel.

TOWN OF KINCARDINE.

At Kincardine, on the shore of lake Huron, a boring in the drift reaches a stratum carrying water in small quantity at a depth of 126 feet, while at a depth of 480 feet a very large supply is obtained in the rock under sufficient pressure to raise it to a height of 25 or 30 feet above the surface of the ground, which at the well is only eight feet above the level of the lake. This water is of good quality, but is not utilized, the town obtaining its supply from the lake.

IN EASTERN ONTARIO.

In the eastern part of the province necessary supplies of water have generally been found on the surface, and hence artesian waters have not been largely sought after. In the town of Lindsay several borings have been made at a level of from 40 to 60 feet above that of the Scugog river, varying in depth from 75 to 125 feet according to the fluctuations of the surface of the ground. One well 4 inches in diameter and 100 feet deep yields under a steam pump at the rate of 25,000 gallons per day. The water in these wells comes from the rock and is of good quality.

An artesian well sunk in the limestone underlying the town of Smith's Falls, county of Lanark, supplies water for public use.

BORINGS ELSEWHERE.

Borings made at Forest, Courtright and other places in Lambton county strike water at a depth of about 75 feet, which rises to within 20 feet of the surface.

In the vicinity of Windsor no good water is obtainable by means of artesian wells, but brackish water is found at depths varying from 60 to 200 feet, which does not come to the surface.

Mr. Hiram Walker of Walkerville has two artesian wells at Marshfield, in South Essex, intended to flood his 200-acre cranberry farm there. They are each about 130 feet deep, and the water rises in full volume to the surface through a pipe of 4½ inches diameter. It is mildly sulphurous. About 10 miles farther east numerous borings from 50 to 250 feet deep have failed to develop water.

East of Essex about ten miles good water is found at a depth of 120 feet, and is also readily obtainable between that town and lake Erie.

A well was bored last year at Ransome's schoolhouse on the Communication road south of Blenheim, township of Harwich, Kent county, to a depth of 135 feet, of which one foot is in slate below the drift. Water was struck at the bottom of the drift, and it rises through an inch pipe three feet above ground. The flow is strong, but noticeably intermittent, owing no doubt to gas pressure. The water has a slight mineral taste, yet it is pleasant and potable. This well is about 100 feet below the level of the gravel ridge at Blenheim.

Numerous flowing wells exist at St. Marys, where they are found in the limestone rock.

Artesian wells have been made use of for years at Waterloo to supply water for private purposes.

West of Port Colborne is a deep well which has for many years been flowing a sulphurous water of good quality, but is now of less volume than formerly. When the water was first struck it was thrown to a height of 40 or 50 feet above the surface.

Artesian water of good quality is also found at Orillia and Bradford in the county of Simcoe, Collingwood in the county of Grey, and Holland Landing in the county of York.

EBB AND FLOW OF ARTESIAN WATERS.

A peculiarity of many of the artesian wells in the country bordering on lakes Huron, St. Clair and Erie is the fact that the water in them rises and falls according to the direction from which the wind is blowing on the lakes. If the wind is strong and continuous off-shore the water lowers appreciably in the wells, while a contrary effect is produced by a wind from the opposite direction. A gale has also the effect of rendering the water in them turbid. These circumstances clearly point to a direct communication with the waters of these lakes, and the fact no doubt is that the water-bearing beds of sand and gravel overlying the rock, as well as the rock itself, are continued out into the lakes and are cut into by the waters of the latter. A wind which drives the water towards the American shore lessens the pressure upon the strata at the Canadian side and consequently permits the water in the wells which penetrate them to fall, while a wind from the American side bringing the water back of course reverses the operation.

MINERALIZED ARTESIAN WATERS.

At various points in Ontario borings have been made which yield mineral waters of varying qualities, some of which have been utilized for their curative properties; but the large majority have either been allowed to run waste or have been choked to gratify the curiosity of the small boy.

VILLAGE OF KINGSVILLE.

Drillings for gas about 2½ miles north-east of Kingsville, Essex county, encountered a flow of water at a depth of 300 feet, strongly impregnated with sulphur and sulphate of magnesia. Two or three miles west of that place a strong flow of fresh water is found before reaching the rock, at a depth of about 30 or 40 feet. At the town itself the rock has been penetrated for 1,000 feet without finding water.

CITY OF ST. THOMAS.

Two wells have been sunk within the city limits of St. Thomas in the hope of finding water suitable for public use. The log of the one sunk at the court house by authority of the county council is given by Mr. James Bell, county engineer, as follows:

20 feet clay, 190 feet hard clay, 30 feet fine putty mixture containing a very fine sand and water, 10 feet hard pan, 33 feet gravel with considerable water, after which the limestone rock was reached and penetrated 7 feet.

The water rose to within 37 feet of the surface, and with a steam pump yielded at the rate of 30,000 gallons per day of 24 hours, the water standing in the well while the pump was working at a depth of 60 feet from the surface. An analysis of the water by Prof. Ellis gave the following result:

Solids	26.040
Chlorine	7.420
Free ammonia	.047
Albuminoid ammonia	.005
Oxygen absorbed in 4 hours	.090

The water is classed as of medium purity.

Encouraged by this result the city council ordered a test to be made in the flats of Kettle creek, about 100 feet lower than the site of the court house, in the expectation of striking a flowing well in the same stratum. Here however the bed of gravel found overlying the rock in the other case was wanting, and the boring was continued into the rock, a black shale being first penetrated, which yielded water, but so strongly impregnated with sulphur as to be unfit for use. Boring was then abandoned, but was afterwards continued by private individuals for about 100 feet farther, the rock proving to be limestone after the first 10 feet.

The well is now flowing at the rate of 8,000 gallons per day, but no use is made of the water, which is so strongly sulphurous as to leave a yellow streak along the sides of the ditch in which it runs.

CITY OF LONDON.

On the left bank of the river Thames at the foot of Dundas street, London, a well was sunk about 30 years ago to a depth of 765 feet, the particulars regarding which were given by Dr. Sterry Hunt in the report of the Geological Survey for 1866.

The strata encountered were clay 70 feet, soft gray shale with a band of hard bituminous shale 20, limestone 600, soft magnesian marl 75. The limestone at 300 feet from the summit was a true dolomite and the marl at the base was also dolomitic, scarcely attacked by cold acids, but effervescing freely by heat. At about 114 feet from the surface two crevices of a few inches each were met with in the limestone, and from this point there is an abundant flow of bright, limpid, somewhat sulphurous water, estimated at 1,000 barrels per hour. This water deposits pure, yellow pulverulent sulphur around its outlet. Its analysis by Prof. Croft gave about two parts in 1,000 of solid matters, consisting of nearly equal portions of sulphates of lime and magnesia, with a little carbonate and traces of chloride of sodium, besides sulphuretted hydrogen. It is worthy of note that the slight sulphurous impregnation previously common to many of the ordinary well-waters of London disappeared on the opening of this great subterranean sulphurous fountain.

The waters of this well have been used for medicinal purposes to a greater or less extent both in the bath and as a beverage for a number of years, and recently a company has been formed under the name of the White Sulphur Springs Company with the view of utilizing them on a more extended scale. The well throws a stream to a height of 40 feet. In a prospectus issued by the Company the statement is made that the well yields at the rate of about 100,000 gallons a day. If this estimate is even approximately correct, there has been a considerable diminution in the flow since the examination made by Sterry Hunt twenty-six years ago.

A number of years ago a well was sunk on the grounds of the Asylum for the Insane to a depth of 2,000 feet. Water was obtained and rose to within 100 feet of the surface, but it was brackish and not fit for use. No record of the strata passed through seems to have been preserved.

TOWN OF CHATHAM.

A well sunk in the eastern end of the town of Chatham about the year 1864 to a depth of 1,000 feet in the hope of finding salt struck a vein of salt water with some oil in hard limestone at 422 feet. Still lower, at about 600 feet from the surface, a copious source of sulphurous water was encountered. Attempts were made to pump the oil, but the volume of water was so great as to prevent successful operations. The water continued to flow for some months, filling a pipe three and a half inches in diameter, and discharging into a neighboring creek, but so strongly was it impregnated with sulphur that the well was voted a nuisance and the owners were obliged to plug it, which they did with some difficulty.

PARKHILL AND VICINITY.

Mr. R. S. Macalpine of Parkhill states that between that town and lake Huron, a distance of 13 miles, there are 50 or 60 artesian wells, varying in depth from 80 to 180 feet, and within a radius of 3 miles from 80 to 156 feet. In a well sunk within the corporation of Parkhill the following strata were presented :

Clay 145 feet, soapstone (so-called) 5 feet, shale 1 foot, hard-pan 1 foot, shale 2 or 3 feet, in which water was found. The water in this well stands at a level of 60 feet from the surface.

Nearly all these wells furnish water in abundance, of varying quality, but generally containing iron, sulphur, etc., in sufficient quantity to unfit it for human use, though cattle drink it readily.

TOWN OF PRESTON.

Artesian borings at Preston are noteworthy from the fact that they have developed a highly mineralized water which is held in repute for its curative powers. Three wells have been sunk there to a depth respectively of 224, 280 and 1,252 feet.

In the first of these, known as the Del Monte springs, the water flows at the rate of 17,280 gallons a day and rises to a height of 12 feet above the level of the river. The water of this well, as well as that of the second, is used in the mineral baths for which the town enjoys a reputation.

The deep well also yields a mineral water which flows at the rate of 11,520 gallons a day, but is used only in flooding a curling and skating rink.

TILSONBURG AND VICINITY.

Mr. Wm. S. Law gives particulars of wells at Tilsonburg, in the county of Oxford, where numerous borings have been made for oil, and latterly for salt, the drill in one case having been put down a depth of 1,947 feet in the hope of striking workable deposits of the latter article.

All the wells bored are flowing, but the water is so highly charged with sulphur or sulphuretted hydrogen and various other mineral substances as to be unsuitable for household use. The water from one well however is in constant use as a beverage, and is also in demand for medicinal purposes.

The water was analyzed by Prof. Croft, and pronounced equal to some other noted waters. All record of the strata passed through has been lost.

Mr. E. D. Tillson adds that nearly all the wells put down some thirty years ago during the oil fever were in the valley of the Big Otter creek, where the blue clay lies in a bed 30 or 40 feet thick, resting upon the limestone rock.

At a depth of about 60 feet in the rock a heavy flow of water was struck, mixed with a little oil. Many of the wells would flow from 30 to 50 gallons per minute, and generally when piped would rise from 40 to 60 feet above the level of the ground; but the water, being mixed with oil and very strongly impregnated with sulphur, was not fit for drinking or domestic purposes, although the product of a few of the wells containing less oil and sulphur was and is yet made use of for drinking. Some people are fond of it and think it conducive to health.

After hopes of getting oil were abandoned some of the wells were sunk to considerable depths in search of salt, a few thin deposits of which were passed through. In most of the deep wells several veins of water were met with, and the deeper the well the more highly charged was the water with mineral substances, in all cases being unfit for use.

About three years ago the quest for oil was renewed, and five wells, varying in depth from 100 to 200 feet, were put down with the same result as formerly, viz: large flows of water and comparatively little oil.

One boring was made on Mr. Tillson's own farm about a mile north of the town, at a point 175 feet higher than the bed of the Otter creek. Here a surface bed of clay 8 feet thick was succeeded by a stratum of coarse sand or fine gravel, as clean and bright as lake gravel, in which at a depth of 18 feet a strong flow of water was obtained, which rose to the height of 10 feet above the ground. The water was clear and of fine quality, with a slight mineral taste, and flowed at the rate of 60 or 80 gallons a minute. Mr. Tillson has connected a three-inch pipe with the well and brings a portion of the water to his farm-house and barn. It is worthy of remark that this flow of good water is found in the superficial beds, while wells sunk in the rock in the valley of the Otter creek below this level produce only water of a decidedly mineral character, unfit for use.

Eight or ten miles north-west of Tilsonburg, in the township of Dereham, a large number of artesian wells have within the past six or eight years been sunk by farmers. In some cases water is reached in the surface deposits, in others the rock must be penetrated, but as a rule good water is obtainable.

MINERAL WELLS IN VARIOUS LOCALITIES.

In the township of Walpole, in the county of Haldimand, numerous artesian wells are put down in the rock a distance of from 25 to 90 feet. An abundant supply of water is obtained, but in very many of the wells it is so impregnated with sulphur as to be unavailable.

At Dunnville in the same county three wells have been sunk, 82½, 80 and 65 feet deep respectively. The water contains sulphates of lime and magnesia, and is unusable. On the opposite side of the Grand river the rock crops out at the surface, and the wells there are not over 10 feet in depth. A peculiarity of the water of these wells is that at certain times it becomes very muddy, apparently as an effect of storms on the lake.

Near Ancaster an artesian well produces a supply of water of a sulphurous character.

No artesian water has been found at Toronto, but along the lake shore a few miles west of the city borings made on the Asylum grounds encountered gas at three distinct levels and a light flow of bitter water in a thickness of over 1,000 feet. A boring made within the last few weeks about a mile to the north-east also struck gas, but reached the Laurentian rocks at a depth of 1,300 feet without revealing the presence of water in appreciable quantity. A bitter saline water was however struck near the bottom of this well.

T. W. G.

THE LAURENTIAN AND HURONIAN SYSTEMS NORTH OF LAKE HURON.

By Dr. Robert Bell, Assistant Director of the Geological Survey of Canada.

This paper is intended to give a brief account of the geology of the country represented on the accompanying map extending from lake Huron northward to lake Temiscaming and from lake Nipissing westward to the Spanish river. It will aim at giving a summary of the various reports of the Geological Survey referring to that region in the light of the most recent views in regard to the rocks of the district, and will cover ground already described by the writer in the annual reports of the Survey for 1865 and 1866, 1875 to 1877 and from 1887 to 1890, by the late Mr. Alexander Murray of the same service in the reports of 1847 to 1857, and by reports made at various times by officers of the Department of Crown Lands.

The geological coloring of the map is compiled by the Director of Surveys in the Department of Crown Lands from the maps and descriptions of Mr Murray, the geological map of the Basin of Moose River, 1883, and that of the Sudbury Mining District, 1890, by the writer, and also the maps accompanying Sir William Logan's Geology of Canada, 1863, as well as from the descriptions contained in the various reports above referred to. As these reports and maps are not very accessible to the public, and some of them are out of print, it is felt that a short summary of their contents, with suitable explanations, arranged in convenient form for reference and illustrated with a geological map, would be found useful at the present time. The colors used are made to harmonize with those at present adopted by the Geological Survey. The topography is compiled from the surveys of the Department of Crown Lands and of the Geological Survey.

With the exception of the larger islands on lake Huron, and possibly a tract in the Sudbury district, the area represented on this map is occupied almost exclusively by rocks of the Laurentian and Huronian systems. Descriptions of these rocks in general and of their relations to each other by the writer are contained in the Section devoted to Geology in the Report of the Royal Commission on the Mineral Resources of Ontario, 1890. But it is now proposed to give a more detailed and local account of the rocks belonging to these systems which are met with in the area represented on the map.

THE LAURENTIAN SYSTEM.

The Laurentian system may be divided into an upper and a lower formation. The latter consists almost entirely of primitive or fundamental gneiss, which is supposed by many geologists to have been originally of an igneous nature, but to have undergone alteration which has produced its more or less foliated character. The upper Laurentian appears to consist of metamorphosed sedimentary strata to some extent at least, while the Huronian rocks are undoubtedly largely sedimentary, but mingled with a varying proportion of igneous rocks, both of which have undergone more or less metamorphism.

METAMORPHISM.

By this term is meant those changes in rocks which have been produced by pressure and heat, and possibly electricity, acting slowly or through a very long time, and producing molecular or chemical interchanges in their constituents, and causing them to become in a greater or less degree crystalline. The original composition of some rocks is more favorable to metamorpism than that of others.

With a change of conditions, rocks may undergo a second or further metamorphism. The element of time being very important in bringing about metamorphism, it follows that the older rocks are the more subject they have been to have undergone this process. The more ancient rocks have necessarily been those most liable to disturbance from the changes which have always been going on in the crust of the earth, so that they have been moved from their original positions and have been tilted, crushed and contorted more than the newer ones, almost in direct proportion to their age. The very fact of strata standing at high angles to the horizon appears to be connected with the metamorphic processes, and rocks which are locally disturbed, as in certain mountain chains, are found to be metamorphosed, while the same strata in continuation are not changed where they are found nearly horizontal. Great outflows of igneous matter have also in many instances had the effect of altering rocks locally.

A crushing and disturbing force due to the constant shrinking of the earth and acting horizontally at the surface has been going on in its crust from the earliest times. The effect of this force may be seen, not only on the large scale, in the tilting, folding up and faulting of the older rocks, but also in their microscopic structure, thin sections of them very often affording the clearest evidence of their having been subjected to intense pressure, forcing asunder solid grains, grinding them against each other or crushing them to small particles. Another effect of the intense lateral pressure referred to has been to produce in rocks a schistose or a slaty cleavage at right angles to the direction of the force. In the crystalline schists this has been effected by the crushing force, aided often by a shearing movement, causing the component particles to move slowly around till their greater diameters assumed positions at right angles to the direction of this force. In the schistose rocks the cleavage planes of such minerals as possess cleavage have been made to correspond with the directions of the mechanical arrangement of the other particles, so that in cross section the whole texture has a parallelism of its grains, giving it a laminated appearance. Dioritic schists have probably been originally massive diorites, and have had their cleavage structure developed in the manner just indicated. Many geologists believe that some kinds of gneiss have been formed out of massive granite in the same way.

These processes involve an enormous lapse of time, so that a crystalline and schistose condition is *prima facie* evidence of antiquity. Indeed if we exclude those cases of local metamorphism which have been referred to, it may be said, in a general way, the more crystalline and altered rocks have become the more ancient they may be presumed to be.

Notwithstanding the apparent stability of the rocks in this part of the world, far removed as they are from volcanic activity, there exists nevertheless within them a state of perpetual unrest. Unceasing changes are going on in the arrangement of their constituents as illustrated by crystal enlargement, pseudomorphism and decomposition in a petrological sense.

Besides the constant internal changes taking place in the rocks, there is restless action or movement on a large scale throughout the whole body of the earth. One of the primary causes of this movement is the constant shifting of the matter on the surface by the action of air and water or ice. The earth is not a rigid solid, but obeys hydrostatic laws. When a certain weight of matter has been transferred from one part to another its effect is to sink down the part to which it has been transported, while there will be a tendency to rise to a corresponding degree at the point which has been relieved of this burden. These oscillations were probably more frequent and rapid in the earlier geological ages than they are now, but they will continue to go on to a greater or less extent as long as air and water exist to transport matter and disturb the equilibrium of the earth.

Divisions of the System.

The lower division of the Laurentian system is characterized by a monotonous uniformity in the nature of its rocks, which consist of gray and red gneiss, usually much bent or disturbed, and having generally only a rudely foliated structure and a solid or massive character. Its felspar is almost entirely orthoclase, whereas the other species are abundant in the upper division. There is a general absence of economic minerals, and the number of mineral species is small as compared with the latter. The upper division is of a more complex or differentiated character, or comprises a greater variety of rocks and minerals. It possesses more regularity in its stratification and includes great banded masses of crystalline limestones, vitreous quartzites, mica and hornblende schists, massive pyroxene, and both massive and foliated labradorite rocks. Considerable areas of granite and syenite occur in the formation. These, as well as the pyroxene rocks, and perhaps also the hornblendic bands, are evidence of igneous action. The dykes of greenstone and porphyry which cut the upper Laurentian may belong to a later geological period.

Upwards of sixty different mineral species have been found among the upper Laurentian rocks in Canada. They also contain a variety of economic minerals, among which may be mentioned graphite, apatite, mica, serpentine and limestone marbles, limestones suitable for calcining, felspar for porcelain, porphyries and other ornamental stones, pyrite, sulphates of barium and strontium, asbestos, crysotile, building stones, and ores of iron and other metals.

It is not impossible that gneiss may have been formed in more than one way. While some varieties, from their microscopical characters and other circumstances, appear to be of clastic origin, it seems to be equally certain that others owe their foliation to pressure and internal changes which may have taken place in rocks of igneous origin. Dr. Sterry Hunt is of the opinion that we have not yet discovered any rocks which can be regarded as having formed part of the original crust of the earth, that is, if we suppose the crust to have been first formed by the mere superficial cooling of a molten mass, since the earliest rocks of which we have any knowledge all contain water and free silica.

The lower Laurentian gneisses are the oldest rocks with which we are acquainted. Their thickness is entirely unknown, and it may ever be found impossible to arrive at even an approximation to their volume. It must however be enormous. The upper Laurentian, of which some kind of measurement is possible, may be roughly estimated in the Ottawa valley, where it has been more studied than elsewhere, at from 50,000 to 100,000 feet, or nearly 20 miles in thickness, and even much more.

Although the older Laurentian rocks may afford no mechanical proof of the permanent existence of a sea upon the earth, unless their foliated or stratiform character be taken as such evidence, water appears to have been present, perhaps as only temporary precipitations upon the surface, at every stage of their formation. But in the upper Laurentian the great deposits of nearly pure carbonate of lime and of tolerably pure silica in distinct bands afford strong support to the aqueous theory of their deposition, while it negatives that of their igneous origin. An important feature in the general character of the Laurentian system is that its rocks, as a whole, are of an acid nature, or contain a preponderance of silica in their ultimate chemical composition. We shall see further on that in this respect they contrast with a considerable proportion of those of the Huronian system, which are largely of a basic character.

Whether we regard the bulk of the Laurentian rocks as having had a clastic or an igneous origin, the general condition of the surface of the earth does not appear to have undergone any great change while they were being formed, or while the cooling process was going on to the extent of their thickness. Even in the upper Laurentian we have found no proof of the pre-existence of solid rock or dry land such as might be afforded by conglomerates.

A PERIOD OF CHANGE.

But with the beginning of the Huronian period came a new order of things. Great volcanic activity took place, and at the same time we have distinct evidence of the permanent abode of water on the surface of the earth and of the wear and tear of the sea on the solid rocks. Immense quantities of volcanic ashes, cinders or tufa, broken rock and other ejectamenta were thrown out, in some cases with explosive violence. Molten matter was poured forth in great quantities from vents and rents in the crust, forming thick sheets and large masses that became incorporated among the marine sediments which were probably accumulating rapidly. The surface of the earth would be almost entirely covered by the sea, which would likely be shallow, hot and full of dissolved mineral matters, the greater part of which have since been eliminated. It would be unfit to support animal or plant life, and it is therefore improbable that we shall ever find any organic remains in this system. Some of the erupted rocks remain massive and unchanged to the present day, except by the internal or molecular action among the constituents themselves, but the bulk of them had become broken up under the strong weathering influences of the period, or by contact with water, and spread out on the bottom of the sea to form the various stratified rocks of the system. The general character of the Huronian rocks may therefore be said to be pyroclastic, this term signifying that although fragmental they have nevertheless had an igneous origin. The Huronian rocks of lake Superior, and the country north and west of it, consist largely of greenish schists which are, chemically speaking, basic as distinguished from the gneiss of the Laurentian, which, as already stated, is of an acid or silicious character. A considerable proportion of the great Huronian belt is made up of greenstones and allied rocks that are also basic.

ROCKS SOUTH OF THE HURONIAN BELT.

In the country represented upon the map, the rocks lying between the great Huronian belt and the shore of Georgian bay appear to belong to the upper Laurentian formation. In the French river region the gneisses are generally characterized by much regularity in their dips and strikes, which often maintain the same course and about the same angle of inclination for long distances. The dips vary from a horizontal to a vertical attitude, but in the majority of cases they are about intermediate between these.

This region is noted for its peculiarly straight and almost parallel rocky channels, many miles in length, having a general course nearly east and west, which are intersected at large angles by other channels almost equally straight, the whole forming a sort of network quite unique in its character. Some of these channels belonging to both sets run with the strike of the gneiss, which when mapped has a sort of zig-zag arrangement on a large scale, while the others follow the lines of the principal set of joints. It sometimes happens that between two leading joint-planes other and parallel joints occur, unusually close together, breaking the rock up into blocks which have been removed by glacial denudation, thus producing these channels. The angles of dip being only moderately steep, those channels which follow the strike occupy ditch-like notches formed along the outcrops of particular sets of beds which have been more easily excavated by eroding agencies than those on either side of them.

It will be observed that the French river flows in two principal east-and-west channels between lake Nipissing and its rocky delta, and that about half way down they both jog to the southward at right angles. This interruption in their course is perhaps originally due as much to some north-and-south break or disturbance in the rocks as to changes in the strike. The long east-and-west channels, whether parallel with or transverse to the stratification, are also probably situated upon lines of crushing, and possibly of some dislocation, along which the strata have been broken up so as to permit of the deeper penetration of the surface waters and the consequent decay of the rock prior to the glacial period, during which these channels have been excavated below the general level of the country. They are really only long and very narrow lakes, with slight falls or rapids between them, and they persist in their courses uninfluenced by the changes in the strike of the rocks they pass through. Besides the channels shown upon the older maps, there are many others in the French river country, all of which belong to the reticulating system of waters which forms so remarkable a feature in this whole district.

The curious rocky delta of the French river has a breadth across its mouths of fifteen miles. The channels, which are very numerous as we leave the coast, form three groups, the east, middle and west, each of which unites by cross channels into one at a short distance up. They are all nearly parallel and have a general northeast and north-northeast course as we enter from Georgian bay. The gneiss in the whole interval covered by these channels runs parallel with them and has a uniform dip to the south-east and east-southeast, with an average inclination of from 40° to 60°. This general strike extends for twenty miles inland from Georgian bay, when it becomes disturbed, and a little further on is cut off by a northwesterly strike in similar gneisses which prevail on the upper part of the French river and the country to the northward of it.

In the central part of the course of the river the strike in different intervals runs about north and south, east and west, northwest and northeast, while between these groups of tolerably straight bands it is often more or less bent or distorted. In some parts of the French river region, even where the strikes are regular, Mr. Murray considered the structure to indicate a series of anticlinal and synclinal folds, in which some of the strata are repeated, and that the thickness of the gneisses is in consequence made to appear much greater than it really is. But after making allowance for this partial repetition, the actual thickness must be very great.

Southeastward of the mouths of French river, along the shore of Georgian bay, the rocks are everywhere well exposed, and the structure of the gneiss and associated strata or their local configuration is well brought out by the erosion to which they have been subjected. This fact is graphically illustrated by the recent charts of Captain Boulton.

Locally the run of the stratification is often indicated by the form or direction of the points and bays, the larger islands and the chains of smaller ones. The curving outlines of the islands, channels and inlets opposite to Penetanguishene, the twisted appearance of Parry island and of the channel on its southeast side, as well as the singular straightness of Partridge bay, the Long inlet, the points on the west side of Parry island and about Shibaishkong island, all correspond with the local strike of the rocks and are due to the effects of denudation, which has formed channels along the courses of the more yielding strata, and left ridges or higher ground where the rocks resisted decay and erosion. Along this shore there is however a class of channels and inlets due to another cause, namely, the existence of dykes of trap and breccia and of granite veins, and also of parallel joints or cracks along which the rocks have been rendered more decomposable; or these latter may have acted merely as starting points or guiding lines for the action of glaciers or other denuding agencies which constantly enlarged and deepened the depressions, once they had been commenced. The channels and inlets of this class usually run nearly east and west and have steep sides, while those which follow the stratification have usually some other course and are not so abrupt.*

These lines of rock-crushing and subsequent erosion have doubtless had a great effect in producing the river and lake features in most of the regions occupied by our upper Laurentian rocks, as well as in some other metamorphic districts of Canada. Dykes of greenstone and breccia have also played an important part in this connection, generally giving rise to river-channels and long lake-basins, but occasionally, where hard or resisting, having the opposite effect, producing ridges, or causing falls and rapids where they happen to cross streams.

Near the head of Byng inlet, a short distance southeast of the mouths of French river, a brecciated rock is exposed near the edge of the water which apparently forms part of an east-and-west dyke, along the course of which the channel of the inlet and of Maganetawan river have been excavated. Parallel to this dyke are joints stained red by oxide of iron, giving a dry and crumbling character to the gneiss along their course, which is east and west, while the gneiss they cut runs in various directions transverse to the joints.

On the lower or western north channel of French river Mr. Murray noticed a friable brick-red quartz-syenite at the Grand Recollet falls and for some miles below it. This probably belongs to an eruptive dyke-like mass, following a line of weakness in the course of the channel.

In the French river country the gneisses are most commonly of dark reddish-grey shades, and they comprise both the mica and the hornblende varieties. Their texture is usually from medium to coarse grained. As a rule the latter are gray and darkly colored, while the finer grained varieties are generally reddish. Silicious belts, in some cases amounting to vitreous quartzites, bands of mica schist with garnets and of hornblende schist occur among the gneisses, and in some localities they are largely developed.

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* Dr. Robert Bell in the Report of the Geological Survey for 1876, page 195.

Veins of coarse reddish and nearly white granite running in different directions cut the hornblende and mica schists and schistose gneisses about the mouths of French river, and similar veins are also met with occasionally in the interior. A few greenstone dykes were noticed along the river, but they do not appear to be very common in this region.

Quartz veins running in various directions are of frequent occurrence in the French river region, but they are all of a "hungry" character, and none of them have been observed to carry economic minerals in promising quantities.

The dividing line between the Huronian and Laurentian systems runs northeastward from the head of Shibaonaning or Killarney bay. Between this locality and the middle of Philip Edward island, including the township of Rutherford and most of Carlyle, the rock is a massive red quartz-syenite or hornblende-granite, which occasionally shows patches of an indistinctly foliated character; but this rock does not appear to extend far inland, although it occupies about twelve miles along the coast. Mr. Murray mentions the occurrence of a similar rock, which seems to have a breadth of about two miles and a length of about four miles, in a northeasterly direction between the western and middle groups of mouths of the French river.

In the region covered by the map certain differences may easily be observed in the general characters of the Laurentian rocks on the southeast side of the great Huronian belt as compared with the rocks on its northwest side, which we have for the present classified for convenience with the same series, because we have not yet found it practicable to separate them by a definite line from the undoubted Laurentian still further northwest, with which they are continuous. Between the shore of Georgian bay and the Huronian belt, and about as far north as the line of the Canadian Pacific Railway, the gneisses are of the typical Laurentian varieties, all evenly stratified and regularly arranged in anticlinal and synclinal forms, according to the structural laws governing stratified rocks. The angles of dip are on an average not far from 45°, although in some cases they are nearly horizontal and in others almost vertical. Except in a few localities the bedding is not contorted, but runs straight and evenly for considerable distances, and these gneisses have every appearance of being altered sedimentary rocks. Red and grey varieties are represented in about equal proportions, and they alternate with each other in both thick and thin sheets. They are mostly mica-gneisses, although the mica is present in rather small proportions, but in some cases hornblende replaces the mica in whole or in part.

No beds of crystalline limestone have been found among these rocks west of the longtitude of Iron island in lake Nipissing, where this rock has been noted by Mr. Alexander Murray. These limestones are also associated with them on some of the islands in the eastern part of this lake and at lake Talon on the Mattawa. Further east, in the Parry Sound district, the writer in 1876 traced five distinct brands of Laurentian limestones running for considerable distances in a northerly direction from the shore of Georgian bay.

The Laurentian rocks between Georgian bay and the great Huronian belt, from the characters which have just been described, would therefore be classified along with those of the counties of Ottawa and Argenteuil, which belong to the upper portion of the system.

ROCKS NORTHWEST OF THE HURONIAN BELT.

On the northwest side of the great belt the conditions are different. At some distance to the northward of this belt the heavy contorted gneisses of the lower Laurentian cover an immense area, but there is an intermediate region in which red hornblende granites prevail, but they are mingled in some parts with gneiss. The granites are largely developed along the northwest border of the Huronian belt all the way from the west side of lake Wahnapitae southwestward to the Sable river, and probably still further. From this geological boundary they extend northwestward out into the midst of the lower Laurentian gneisses to a variable distance, their greatest extension being unknown. Along the main line of the Canadian Pacific Railway they are found all the way from the junction of the Huronian at Onaping station to Spanish Forks and westward from the railway to the Spanish river, but beyond these limits the country has not been carefully explored.

Similar red hornblende granite, occasionally showing gneissoid texture, forms an elongated area in the middle of the Huronian belt in the Sudbury district, extending from near the South bay of lake Wahnapitae southwestward to the township of Drury. The southern boundary of the main granitic area crosses the Spanish river midway between the northern and southern lines of township 111, whence passing westward it sweeps round to the south and forms a promontory in the townships of Gough and May. From the northern part of the latter township the boundary between the granite on the north and the Huronian quartzites, greywackes and schists on the south runs westward parallel to the shore of lake Huron, as far as the township of Proctor, were it turns northwestward and the Huronian rocks occupy a large area lying to the northward of Algoma Mills.

Although the granites which have just been described are provisionally classed with the Laurentian, it is uncertain that they are all really of this age. In some localities they are so intimately associated with gneisses of the ordinary Laurentian types that it would be impossible to draw a line between them. In such cases they may have been formed out of portions of the gneiss softened by heat and re-crystallized after having lost their stratiform character. In other places it is quite possible they may be due to the alteration of arkose or greywacke similar to that which is so common in the adjacent Huronian series. Or it may be that these granites are mainly eruptive in their origin. The writer has pointed out in various reports on the Archæan rocks of northern Canada that the commonest situation of the granitic areas among these rocks is at and near the junction of the Laurentian and Huronian series, and there is perhaps no good reason yet known why they should be assigned to the one more than the other.

In the region at present under consideration, along the line of contact between these granites and the Huronian quartzites, schists, etc., the rocks are often much broken up and intermingled with one another, both in great masses and smaller fragments. This effect has probably been produced when the granite was in a soft condition and subject to intense pressure, coupled with more or less movement. Referring to the last mentioned consideration, it is not improbable that faults of considerable extent have taken place along the lines of junction between these two classes of rocks, not only in this region but in other localities where the Laurentian and Huronian rocks come into contact. This is only what we might expect to occur along the lines dividing rocks having unequal powers of resisting the great strains to which the crust of the earth must have been subject in all ages. These faults may be looked for more especially at those parts of the junction of the two sets of rocks which have been most exposed to lateral pressure, and along those portions of the lines of contact which are tolerably straight for considerable distances. The bed-planes of the Huronian and Laurentian rocks on the opposite sides of a contact thus faulted might show some want of parallelism, and from this accident a general unconformity of the two series might be erroneously inferred. The few instances of apparent local want of conformity which have been observed seem to be capable of explanation in this way. One of these instances may be seen at the Wahnapitae river where it is crossed by the Canadian Pacific Railway.

Within the area represented on the map, besides the gneissic and granitic rocks flanking the great Huronian belt, there remain to be noticed a few inliers of these rocks. One of them, consisting of gneiss, lies between the north and northeast arms of Temagami lake. Another, also of gneiss, which has been described by the writer in the report of the Geological Survey for 1875, surrounds Paul's lake on the upper part of Sturgeon river, and appears to extend for some distance to the south of it. A short distance east of the angle formed by the junction of Proudfoot's east-and-west and north-and-south lines an area of red hornblende granite was discovered, which may extend to the northward, but its limits have not been traced out. Two belts of gneiss projecting from the northward cross Montreal river, one at Elk lake and the other at the sharp turn in the river about midway between this lake and the junction of the east branch. Both of these belts appear to terminate at no great distance to the south of Montreal river.

THE GREAT HURONIAN BELT.

Sir William Logan and his assistant, Mr. Alexander Murray, after examining the crystalline rocks of lakes Superior and Huron, gave the name Huronian (at the suggestion of Dr. Sterry Hunt) to all those of both regions which lie above the granitic series which they called Laurentian. These terms were not restricted to any particular area, but were meant to designate the two great divisions of the Archæan rocks and to be of general application in Canadian geology. Both sets of rocks extend into the United States and the Canadian names, having priority, were adopted there. But of late years efforts have been made to abolish the convenient and well established designation Huronian, except for one small area of these rocks lying on the north side of lake Huron and forming only a part of the great belt which is continuous from lake Superior to lake Mistassini, a distance of 700 miles following its axis, on the asserted ground that the selected part alone forms what some geologists call the "typical Huronian." I cannot however understand why one particular portion of one belt of rocks of the Huronian system should now be selected for this distinction to the exclusion of the remainder of the belt which is continuous with it, and also of other areas of rocks which are most naturally placed with them and which were expressly included by Logan when he classified them and gave them this name.

The rocks of the Huronian system as defined by Logan consist of crystalline schists in great variety, quartzites, conglomerates and agglomerates, clay-slates, greenstones, dolomites, etc. At the time referred to, more than forty years ago, the science of petrology was in a crude state compared with its present position, and the microscope was but little used in determining the nature of rocks. Hence Logan did not recognize the volcanic or rather pyroclastic character of a large proportion of the Huronian rocks. Some of the rocks of the system, such as the quartzites and clay-slates, although they do not themselves show a direct igneous origin, may have been derived from the products of volcanic activity through the intervention of water.

Owing to the pyroclastic origin of the majority of these rocks the various members in any region are not usually persistent for any great distance, but diminish in volume and are replaced by other beds which increase in thickness as the first diminish. As these rocks are usually tilted to high angles, the sections afforded by the surface of the earth are generally nearly at right angles to the bedding, and when mapped often show the interlocking character of the different bands as they terminate in both directions. This want of persistence is exhibited on both a small and large scale, so that the general characters of wide belts of Huronian rocks differ much in different regions.

In other parts of the world, such as Scandinavia and Scotland, where Archæan rocks are largely developed, series corresponding with our Laurentian and Huronian are met with. Nowhere have rocks of a different character been found to intervene between them. We might therefore infer that in a general way the two systems are conformable to one another. This inference is borne out by our observations over the enormous area of Archæan rocks which we have in the Dominion. It might be expected that in some parts of this great area a local want of conformity might be detected at the same time that the two systems were conformable on the grand scale. But in the few instances where there appears to be a want of parallelism in the stratification on the opposite sides of the contact, this is more probably due to faulting.

On the other hand, we have observed numerous instances where there is a gradual and conformable transition from the lower into the upper series. The beds of passage as a general rule consist of hornblende and mica schists alternating with fine-grained gneisses, and these are followed by other crystalline schists. In the Huronian areas of lake Superior crystalline schists predominate, although representatives of all the other varieties of the rocks of the system are not wanting, while in the lake Huron region and to the northeastward of it greywackes and quartzites with clay slates are the most conspicuous rocks, but the various crystalline schists similar to those of the lake Superior region are likewise to be found.

An impression has got abroad in some quarters that one of the distinguishing features of the Huronian rocks on the north side of lake Huron is that they usually dip at very moderate angles. Even if this were true, it would be a matter of no consequence in chronological geology. It is however only an incorrect assumption, and on the contrary as a rule the rocks of that region are highly inclined, as shown in a section by Mr. Murray in the report of the Geological Survey for 1856, and in my own section across the Sudbury district published in 1891. They do however dip at low angles in certain limited areas, such as the tract lying northward from St. Joseph's island and in that situated to the east of lake Wahnapitae, and again between lake Temagami and the Montreal river. But instances of equally low dips are to be seen among the upper Laurentian gneisses, as for example in a large region to the northward of Montreal.

Although in the lake Superior region and thence westward to Lake of the Woods the Huronian rocks consist so largely of crystalline schists, still there are silicious rocks among them, which may be the equivalents in diminished volume of the quartzites of lake Huron; also conglomerates, clay-slates, serpentines, dolomites, etc., and on the other hand there is an abundance of crystalline schists among the Huronian rocks of the lake Huron region. Conglomerates occur at various horizons among these rocks in both regions, but any single conglomerate bed is probably only of local occurrence and cannot be held to be the equivalent of any particular conglomerate in another region. As these conglomerates cannot be connected with one another in different Huronian areas it can scarcely be said that they represent a general break in the chronological continuity of one part of the system with another, much less a time break between this system and any other.

From what has been said of the nature of the Huronian system we should not expect even contemporaneous parts of it to be everywhere represented by the same kind of rocks. On the contrary, great local differences might be looked for at the same horizon. In a given region one variety may be largely developed, and yet in another this may be entirely replaced by a different rock without there being any difference in the age of the two. Rocks like those of the Lake of the Woods may be the equivalents in time of those of the north side of lake Huron, or of some other part of the system where the lithological difference is equally great. Still we have always admitted that perhaps the prevailing schistose series of the lake Superior region may belong to an older part of the system than the quartzite, clay slate and greywacke series of lake Huron, which apparently forms the newest portion of the great belt. Thus the area characterized by the great development of quartzites in the region extending from lake Huron to lake Abittibi may be somewhat newer as a whole than those portions of the series where the quartzites are in small amount or entirely absent. At the same time it is not to be forgotten that the quartzites of the region mentioned are associated with a variety of crystalline schists, such as may be seen on Spanish river, around Temagami lake, on Montreal river and in the region to the northward of it. The stratigraphical sequence of the various kinds of rocks found in the Huronian belt within our region has not yet been ascertained with sufficient certainty. The following descriptions of these rocks are therefore not given in the supposed order of their superposition.

QUARTZITES.

It is an interesting fact in connection with the origin of these rocks that the quartzites and clay slates are so often found together. The decomposition of the arkose or greywacke and the separation of the silicious grains and the clayey portion would give rise to these two kinds of rock. Or they might result from the decomposition of the binary granite, from which the greywacke itself is probably derived, by the separation of the quartz grains from the argillaceous matter that would be produced from the felspar. Nearly all the quartzites contain more or less felspar, and sometimes it is present in large proportions, giving the rock the general outward appearance of granite. In some instances observed by the writer this mixture had become so far metamorphosed back into granite that it required to be examined in thin slices under the microscope before it could be decided that it had ever been a clastic rock at all.

These highly felspathic quartzites are abundant along the North river canoe-route from lake Mattagamashing (just east of lake Wahnapitae) to the upper part of Sturgeon river, and again west of Lady Evelyn lake, which lies north of Temagami lake. In other regions however the proportion of felspar in these rocks is generally small, and the texture of the nearly pure quartzites varies from compact with conchoidal fracture and composed of microscopic grains up to coarsely granular, made up of small pebbles closely crowded together. Some beds in almost every large outcrop of these rocks are of a distinct conglomerate character, the pebbles being well rounded and almost all of white quartz.

In the country just north of Bruce Mines, and again on the north side of Goulais bay, lake Superior, some beds and groups of beds of these conglomerates contain pebbles of red and dark jasper and light-colored chalcedony, thickly scattered among others of white quartz, all in a matrix of white quartzite. This beautiful rock has long been known as jasper conglomerate, and forms a fine ornamental stone, but owing to its hardness it is expensive to cut and polish. A few scattered pebbles of jasper are found here and there in the quartzites all the way from the above localities to Montreal river.

Light grey and nearly white quartzites form the north shore of lake Huron from the mouth of Spanish river eastward to Killarney bay. They constitute the LaCloche mountains, which run as two and sometimes three parallel ridges close to the shore, and nearly due east and west with the strike. The height of the front ridge varies from 400 to 755 feet above lake Huron, but the altitude increases in the continuation of these hills to the eastward, and it rises at one point to an elevation of 1,180 feet. The dip is everywhere nearly vertical. Similar quartzites, also standing nearly on edge, form the long and high points jutting out into lake Huron in a southwesterly direction between McGregor and Killarney bays. The strata forming these points are probably repetitions of those of the LaCloche mountains, on the opposite side of a synclinal ot nearly vertical strata, one extremity of which would be in the vicinity of the east end of lake Panache. The quartzite of the points and islands south of Frazer bay continues southwestward, and appears on Heywood island, and further on upon Grand Manitoulin island, at the head of Sheguiandah bay, and thence past the northern sides of Bass and Pike lakes. Quartzites, mostly of light colors, constitute the prevailing rock around lake Panache and the great bend of Spanish river, and northeastward to the township of Broder, but beyond this, for some distance on the general strike, they diminish in volume, and a considerable proportien of what remain merge into greywackes in passing through the contracted part of the belt in the Sudbury district. Still further on in the northeastward strike, or in the country to the eastward of lake Wahnapitae, the greywackes have passed into or have been replaced by clay-slates and argillites, dipping at much lower angles.

Northward of lake Wahnapitae the quartzites are again met with in great abundance Along the upper Wahnapitae river they strike north-northwestward parallel to the Laurentian boundary in that direction, and dip at high angles. On the North river chain of lakes the general strike is east of north, turning more easterly in approaching Sturgeon river, beyond which the quartzites run northeasterly towards Lady Evelyn lake and Maple mountain to the west of it. These rocks are exposed in numerous places along the main Montreal river, and both its branches south of the great bend. Still further north they are largely developed in the country along the height of land westward from its intersection with the north and south inter-provincial boundary line.

In the region northeast of the St. Mary river the quartzites show considerable differences of color, and on this ground Mr. Alexander Murray separated them into different bands. In the southern part of the district shown on our map they are nearly all of light shades, but near its northern border there are red, pink and purple varieties. These are however of local occurrence. Greenish and yellowish tinges are common in all parts of the distribution of the lighter varieties.

CLAY-SLATES AND ARGILLITES.

The term slate should be given only to rocks formed principally from clay, in which arallel cleavage planes have been developed independent of the bedding. It is not properly pplied to those crystalline schists in which the cleavage is more or less imperfect and the planes are not parallel to one another. Argillites are claystones in which the slaty cleavage has not been developed.

Confining our remarks always to the area represented on the map, rocks of these two kinds are met with most largely in the country between lake Wahnapitae and Sturgeon river, along that stream between the Maskinongé and Round lake branches, about the north end of Temagami lake, and thence by Lady Evelyn lake to Montreal river, and on the latter; likewise along the Matabechawan river, which discharges into the foot of lake Temiscaming. These slates are mostly of olive or bluish green, purplish, drab and gray colors, and are often barred across the cleavage with narrow parallel bands of different shades. At the northern outlet of Temagami lake a greenish compact variety is marked by thin interrupted black bars. This rock, when cut, takes a smooth surface, and was much prized by the ancient Indians for ornaments and ceremonial stones.

These principal accumulations of slates and argillites appear to be in a general way about contemporaneous with the quartzites, that is to say, they were being deposited in the above localities at the same time that the quartzites were forming in others. Where they occur in smaller volumes they are sometimes found in proximity or interstratified with one another. As already stated, they may both be derived from the greywackes, which form so large a proportion of the rocks of the great Huronian belt in this region; and the greywackes in their turn are evidently made up of the *debris* of a quartz-felspar rock or binary granite. Or they may have been formed directly from the decomposition of this rock and its rearrangement by water, the silica and the undecomposed felspar, when any of the latter remained, going to make the quartzites, while the fine mud resulting from the decay of the felspar was carried elsewhere, and now constitutes the slates and argillites. As far as our present knowledge goes, the quartzites therefore cannot be said to be either older or newer than the slates of this part of the Huronian series.

The roofing slates found among the metamorphic rocks of the Eastern Townships in the province of Quebec are probably of somewhat newer geological age than those just described, which in some places may be found suitable for roofing purposes. Among the localities where the argillites or non-cleavable varieties occur may be mentioned the southern part of Mattagamashing lake, Koo-ka-gaming and Lady Evelyn lakes. Good cleavable slates occur on the Canadian Pacific Railway a short distance east of Algoma Mills. Felsites are sometimes found associated with the slates and quartzites, but they are more abundant among the greywackes.

Dark gray or drab and almost black clay slates are found along the Spanish river, in the northern part of Baldwin, and at the falls on lot 1, fifth concession of Nairn. Similar slates are met with on the Canadian Pacific Railway in the southwestern part of Graham, and again just south of Geneva lake. They are also said to occur in the township of Drury and a short distance east of Bannerman lake.

GREYWACKE OR ARKOSE.

In some parts of our region a rock which may be described under either of the above names is met with in great abundance. It has some resemblance to sandstone, but does not usually occur in distinct beds with parallel faces, and is generally either massive or divided by joints or a rough sort of cleavage. Under the hammer it breaks readily, and may be easily bruised or scratched, thus showing the presence of a considerable proportion of ingredients softer than quartz. It has an ashy appearance, and its color is usually some shade of ash-gray. On closer examination it is found to consist of comminuted granitic *debris*, and generally holds quantities of pebbles and angular fragments of all sizes of the granite itself. The latter are mostly of the same character in all parts of the district, and consist of a binary granite or quartz-felspar rock of either a red or gray color. Fragments of gneiss and other crystalline rocks are occasionally mingled in small proportions with those just described. Under the microscope the matrix or finer portion of this rock is seen to consist of somewhat rounded grains of quartz, and more angular ones of felspar, with a filling of fine serecite or of some dark amorphous mineral.

Rocks of this kind occur here and there in almost all parts of the Huronian belt within our region, but they are particularly abundant in the narrowed portion in the

Sudbury district and around Temagami lake and Rabbit lake to the east of it. They are also common in the Onaping and Straight lake outliers and all along the Spanish river, below the granite area, and thence westward as far as Mississaga river.

Sometimes, as on the Montreal river, the included fragments of granite attain the size of boulders, and these, as well as the smaller inclusions, may occasionally be found so closely packed together that only the interstices are filled by the finer material. The fragments are most common in the greywackes where the latter occur in large volume, and in these cases there is little evidence of stratification. The more uniformly-grained varieties, without angular fragments, are often found interstratifying quartzites, as in the Sudbury and Whitefish lake regions, and they may be seen containing every proportion of quartz grains till they themselves become quartzites.

There was no doubt great volcanic activity on the earth at the time these greywackes and their associated rocks were being formed. The thick unstratified and brecciated masses of greywackes may represent volcanic ashes or mud with stones thrown out upon the land or in shallow water, while the stratified varieties may have been similar ejectamenta thrown into deeper water and modified by the currents or waves of the sea. Some of these rocks, whether stratified or otherwise, may represent volcanic products which were originally poured into the sea in a molten condition and became broken up and disintegrated. The glass breccia already referred to as forming such a thick belt in the Sudbury district is direct proof of volcanic activity with explosive violence on a scale probably grander than any such action in modern times. Even without this and many other proofs which might be cited from the earliest records of the rocks themselves, it would only be in accordance with the general geological history of the globe to believe that volcanic or igneous action was going on upon the surface more generally and on a greater scale in the earlier than in the later geological times.

From a study of the greywackes and the rocks associated with them there would appear to be little doubt that the former constituted the crude material from which the quartzites and clay-slates were derived by the modifying action of water. Again by the action of time, pressure, heat, electricity, and perhaps other metamorphosing agents upon different varieties of greywacke, some of our granites, syenites, gneisses, felsites and possibly other rocks were formed. Many instances were noted in the Sudbury district where the more massive greywackes exhibited a proneness to revert to granite again, while some of the stratified varieties showed different stages of their passage into gneiss, and again certain of the finer-grained and more homogeneous kinds had been altered into felsites.

SLATE-CONGLOMERATE.

Some of the argillaceous varieties of the greywacke containing pebbles of granite, and occasionally some of quartz, jasper, etc.,and having more or less slaty cleavage, were called slate-conglomerates by Mr. Alexander Murray, and he even extended this term so as to include massive brecciated forms of greywacke, which show no cleavage at all. This name was also given to certain Huronian schists containing rounded pebbles and boulders, and likewise to dioritic schists full of lens-shaped inclusions parallel to the cleavage or bedding, and which in cross-section look like elongated pebbles but which may be of a concretionary character in the majority of cases. They are often inconspicuous or difficult to distinguish on dry surfaces of the rock, but when wet are quite distinct, having a lighter color than the matrix. But they do not appear to differ much in composition from the rest of the rock. These rocks, which have sometimes been called dioritic schist-conglomerates, are very common in the lake Superior region, but they appear to be scarce in our present district.

IMPERFECT GNEISSES.

Imperfect gneisses are met with in most of the Huronian areas in both the lake Superior and lake Huron regions, but they always occur in limited quantities. They differ from the Laurentian gneisses in being usually finer grained and less perfectly crystalline. Under the microscope they sometimes show traces of clastic origin. In all of the numerous cases tried by the writer it was found that they invariably contained carbonate of lime, whereas the Laurentian gneisses are seldom calcareous. Where their crystallization has been coarse enough to observe their felspars easily these have sometimes proved to be of triclinic species, while the felspars of the Laurentian gneisses are chiefly orthoclase.

GREENSTONES.

Within that portion of the great Huronian belt which traverses our district are numerous areas of greenstone, varying in dimensions from masses too small to define on the map up to others many miles in length. The word greenstone is used in this paper to include a variety of trappean rocks which cannot always be distinguished from one another in the field. These crystalline masses have often undergone metamorphism as well as the sedimentary rocks, and it sometimes happens that even a microscopic and chemical study of them in the laboratory fails to prove what their original condition has been. The term greenstone, which includes them all, is therefore a very convenient field-name. In the Sudbury district they consist of diabases, diorites and gabbros. The last named constitute some of the dykes, while the others shade into each other, and as a class may be divided geologically into three groups.

The first of these consists of masses of highly crystalline dark green diorite (sometimes passing into diabase) of medium texture and holding disseminated specks and spots of pyrite, pyrrhotite and chalcopyrite. These masses occur principally among the greywackes, quartzites and clay-slates, and with few exceptions their greatest lengths are in the direction of the general strike of the surrounding rocks. They may have been originally laid down as molten sheets in nearly horizontal positions with the enclosing strata, and subsequently tilted to the present high angles of inclination. In a few cases the lower surface of a greenstone mass may be seen filling inequalities which seemed to have been worn in the underlying rock prior to the advent of the greenstone. As these masses appear to have become incorporated with the strata before the latter had assumed their present positions it becomes uncertain that they are all intrusive, although some of them probably are so, but their original positions with regard to the horizon have been changed owing to the subsequent folding which has taken place in the crust of the. earth. Greenstone masses of this kind are found in the Huronian belt all the way from the shore of lake Huron northward to the border of our sheet, and thence for a great distance towards James bay. They are numerous and often large in the Sudbury district, where upwards of fifty occur, and also around lake Tamagami and in the valley of the Montreal river, but towards lake Huron they become smaller and do not form so prominent a feature in the geology of the region as they do further north.

Our second variety of these rocks has a grayer color and more coarsely crystalline texture, while the disseminated specks of metallic sulphides are not by any means so abundant as in the first. Its composition appears to be always that of a diabase. This rock forms three distinct belts among the granites and gneisses of the Sudbury district, and they appear to cut through them as intrusive masses. They all run northeast and southwest.

Windy lake on the main line of the Canadian Pacific Railway lies upon the central portion of the most northwesterly belt, which has there a breadth of about one mile, but narrows to a point in the northeastern part of Levack on the one hand and in Trill on the other, the total length being about eighteen miles. The second belt runs northeastward through Morgan towards Sagi-tchi-wai-aga-mog lake, while the third runs from the township of Creighton to the vicinity of Whitson lake.

The third variety differs from the first mainly in being schistose in some parts, and in frequently containing rounded and angular pebbles and masses of all sizes and of various kinds of rocks, but especially of quartzites, other varieties of greenstones, granites and greywackes, thus constituting agglomerates and breccias. These portions appear to run in ill-defined bands about parallel with the longest diameters of the masses. The greenstone belt which extends from Garson to Graham belongs to this class, as do also the areas of this rock in the fourth and fifth concessions of Denison. All these lie against the southeast side of a long granitic area, and it may be that they have suffered more from lateral pressure coming from the southeastward than the dioritic masses described under the first division, which may have been protected by the more yielding rocks with which they are surrounded. Examples of the greenstone agglomerates and breccias referred to may be seen near the Blezard, Stobie, Copper-cliff, Crean and Vermilion mines, and also where the main line of the Canadian Pacific Railway crosses lot 8 in the fourth range of McKim, and again where it crosses lot 5 in the fifth concession of Moncrieff.

DIABASE DYKES.

Dykes form an interesting feature among the rocks of our district, and they may also prove to have some bearing upon its economic geology. They consist of gabbro and olivine diabase, and are of rather frequent occurrence in some sections. As far as direction is concerned they may be said to belong to two sets, the course of one varying from west-northwest to northwest, and of the other from north to north-northeast. Most of them decompose more rapidly than the containing rocks, and their positions may be recognized by the depressions they form on the land and the channels in the lakes. On the shore of lake Huron some of those belonging to the northwesterly set may be seen in the vicinity of Shibaonaning or Killarney, and around Frazer bay. Many dykes of both sets are shown on the geological map of Sudbury district by the writer. Around Ministic lake in Ermatinger and Cascaden, where a number of them cut the gneiss, their general course is northwest. Almost in continuation of these, a large dyke at the junction of Agnes river with the Spanish in township 108 cuts the granite there in the same direction.

Dykes belonging to the northwesterly set may be seen here and there along the main line of the Canadian Pacific Railway between Sudbury Junction and Straight lake. Between Sudbury and the Murray mine and again between Windy lake and Cartier station they have facilitated the building of the line by the depressions which now mark their courses through the rocky hills whose general course lies across that of the railway. In the granitic region between the Onaping and upper Vermilion river dykes belonging to both sets are met with. A large dyke running north-northeast crosses the Vermilion river near the middle of the east line of township 66.

The basin of Onaping lake appears to be excavated along the course of parallel dykes cutting the granite and gneiss in a northerly direction. The lake is about twenty-six miles long, and except towards the south end is very narrow. In some parts the shores are formed by the dyke walls, to which patches of greenstone are still adhering. A large dyke running a little west of south is traceable along the east side of the southern part of the lake. A dyke which may be a continuation of this occurs also on lot 4 in the third concession of Moncrieff.

A short distance north of the head of Onaping lake we pass over the height-of-land and come to the head-waters of the Mattagami river, which flows northward in nearly the same longitude and falls into the western side of the lake of the same name. Mattagami lake has about the same length as Onaping, and is also narrow. Its outlet flows northward in the continuation of the valley, and at about seven miles falls into the head of Kinogamissé lake, another long narrow sheet of water, also running north and south and having a length of twenty-two miles.

On the course of the river connecting Mattagami with Kinogamissé lake a great north-and-south dyke makes its appearance, and below the latter lake large dykes, cutting the Huronian and Laurentian rocks and all having a northerly course, are met with at intervals along the Mattagami river until it enters upon the Silurian and Devonian basin extending to James bay. Several of these occurrences may be only different sections of one great dyke. Some of them are 300 to 400 feet wide. They are more compact near the walls than along the centre, which has been more easily eroded and in some parts forms the channel of the river.

The head waters of Moose river, from the Missinaibi to the Abittibi, covering a breadth of 120 miles in the lattitude of Abittibi lake, comprise upwards of a dozen nearly parallel north-flowing branches which afterwards converge to form the main river. The Montreal river is remarkable for drawing its waters from several nearly parallel streams, also flowing north, but they fall into a valley in which they are immediately turned round to the eastward through more than a right angle and pursue almost a straight line southeast to the Ottawa. The north and south valleys of these streams belong, as far as their origin is concerned, to the same set as the extraordinary parallel valleys of the basin of Moose river. Dykes and elongated masses of greenstone with a general north-and-south course were found along both the east and west branches of the Montreal river, and it may be assumed that they also exist along the other parallel tributary streams and lakes of this system.

As far as our present knowledge goes, this parallelism of the water-courses in both the hydrographic basins which have just been named is due to the guiding influence on eroding agents of the large greenstone dykes with which the whole region is seamed. There is no doubt that dykes like these have played an important part in determining the present topographical features of this part of the country. Previous to the glacial period the dykes probably decomposed to a greater depth than the enclosing rocks, and when the ice passed over the land the trenches which would soon be excavated along them under this powerful denuding agent would act as guiding lines for further erosion, and the depressions along them would become deepened and enlarged until they had formed the various lake basins and river valleys that lie upon their courses. In the upper parts of the Moose and the Montreal river basins the general direction of the glaciation was sufficiently near that of the great dykes which have been mentioned for it to adjust itself locally to them.*

These dykes, whether of diabase or gabbro, when undergoing decomposition at the surface weather into rounded boulder-like masses, the result of the disintegration and crumbling away of their angles and edges along the joints which had originally divided them into blocks. After they have been reduced to the rounded form they scale off in concentric layers, and this gives them a concretionary appearance. This is a common characteristic of such dykes everywhere, and often causes their outcrops to resemble rows or ridges of boulders. When fresh, both of the above-named dyke-rocks are very tough or difficult to break. The gabbros are as a rule of a lighter color, and resemble granites more than the diabases do; but they are generally deeply penetrated by the effects of the weather, which gives them a brownish discoloration, and it is only when deep-seated or completely unexposed portions are broken that the true color is seen. One of the principal differences between the two rocks is that in the gabbros the augite or pyroxene takes the form of diallage.

MICROSCOPIC CHARACTERISTICS.

Samples from both these varieties of the dykes of the region have lately been examined microscopically for the writer by Professor George H. Williams, lithologist of Johns Hopkins University, and in order to convey a correct idea of their structure, composition, etc., we cannot do better than quote a description of each by this distinguished authority.

On the Spanish river, opposite the foot of the 5th portage, or just below the junction of the Agnes river, in township 108, there is to be seen a dyke of medium-grained gray olivine diabase 240 feet in width, running north 40° west, from which a specimen was submitted to Prof. Williams. He says:

> The microscope shows this specimen to be a fresh aggregate of olivine, reddish augite, plagioclase and ilmenite, with accessory apatite and biotite. Its diabase or ophitic structure is very typical. The olivine in this rock is remarkably fresh. It is in small pale yellow grains, which rarely show external crystal boundaries. It has a very high refractive index, no pleochroism and contains glass inclusions. The augite is of the reddish and slightly pleochroic variety common in diabase. It not uncommonly shows zones of growth, having different shades of color. In form the augite is allotrimorphic, filling the interstices between the laths of plagioclase. The felspar (probably labradorite) is idiomorphic, and forms an interlacing net-work of lath-shaped crystals. It is

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* The agency of dykes in forming a river valley is sufficiently clear in the case of the Mattagami river, one of the parallel branches of the Moose, and which has been already described.

the only constituent that shows any alteration, and this is comparatively slight. Th opaque iron oxide is probably ilmenite. It is without distinctive form or alteration, and sometimes surrounded by a narrow rim of biotite. Apatite is abundant.

At the Dominion Mineral Company's mine on lot 4, second range of Blezard, there is dyke from 30 to 50 feet wide, running north 35° east, a specimen from which is describe by Prof. Williams as a quartz hypersthene gabbro with accessory biotite. He says :

> The microscope shows this to be an eruptive rock of quite exceptional character a interest. It belongs to the general type of gabbros, but has traces of a diabase-like stru ture in its long idiomorphic felspars; is related to the norites by the abundance of i hypersthene, and contains what is exceptional for all of these rock-types—an abundance original quartz. The rock is quite fresh, but shows the effect of dynamic action in t bending of felspar crystals and the uralitization of the pyroxene. The felspar is in sto lath-shaped crystals of good size which produce a coarse ophitic or diabase structure, in many of the well known Scandinavian gabbros. They present a brownish color in t thin section from an abundance of ultra-microscopic dust-like inclusions. They exhibi in a beautiful manner the effect of strain, in the bending of the crystals and the produ tion of secondary twinning lamellæ. The pyroxene is both monoclinic (diallage) an orthorhombic (hypersthene) in about equal amounts. Both are undergoing alteration int compact green hornblende. The mica is an intensely pleochroic biotite. It is abundantl present in large flakes of irregular size and has all the properties of an original constituen Quartz is also quite abundant in large clear grains of irregular shape, and was apparentl the last mineral to crystallize. Apatite, zircon and magnetite are also present in consid erable amount. This rock, although a typical gabbro, is unusually acid and approache in its quartz and zircon to the augite granites.

Lines of Crushing.

In the region we are considering the effects of cleavage and bedding, fissures an joints, rock-crushing, intrusive dykes, etc., on the topography are so well marked that i is worth directing attention to some points in connection with the subject. The joint fissures and dislocations of the rocks in any given district generally run in two sets, thos of each one being nearly parallel to one another. One set is usually more strongly marke than the other and exercises an important influence in the decay and disintegration of th rocks, and this in its turn affects the contours and other topographical features of th district.

Greenstone dykes, even when thin, are often remarkable for persistence in lengt They are also often parallel, or nearly so, and transverse to the strike or cleavage, and i these respects are allied to both joints and dislocations. This is only what might hav been expected, for the igneous matter could not have come up from below to form the unless the rocks had first been rent. The forcing asunder of the walls of the origin fissure or joint may have been due to the hydrostatic pressure of the molten matter itsel which must have been very great on such extended surfaces. In the various process of decay, denudation and erosion of dykes, joints—fissures and dislocations have co-operat to produce parallelism in the natural features of many parts of our district, as well as i other regions underlaid by crystalline rocks.

Among Archæan rocks evidence of intense pressure is almost universal, which not the case with regard to the newer and undisturbed strata. When thin slices of the rocks are made, so that their elementary structure may be examined under the micr scope, it is found that in some parts they are crushed, while in others there is eviden that they have been slowly stretched, proving that they have been subjected to great a long continued strain. In this process the patches and grains of rock had time to co stantly adjust themselves, and they have been kept firmly cemented together by the co tiguous mineral matter, so that the strength and outward firmness of the rock have n been affected by this internal rearrangement of its component particles, and therefo when lithologists speak of a rock as "crushed" they do not mean that its present streng is weakened. But this latter state has been produced along certain lines of more rece movements affecting only the present outward condition. This phenomenon will be mo fully described further on.

Although the textural crushing just described may be detected so generally amo the ancient crystalline rocks, it is particularly manifest at points unusually exposed the action of the forces which produced it. One of these occurs on the west side of lake Wahnapitae, where a promontory of the granitic rocks projects into the Huronian belt at its narrowest point.

The spaces which have been left by the inequalities along lines of fracture after dislocation in certain Archæan rocks have sometimes been filled by the debris ground off the walls, and which now forms dykes of breccia. An example of these may be seen at the first rapid in the Maganetawan river, eastward of the head of Byng inlet. The breccia dyke runs eastward with the course of the stream. Its matrix is amorphous and very brittle. Some of the fragments consist of a dark reddish-brown opaque cherty rock, and others of a dark variety of syenite. The mass holds a little calcspar and specks of iron pyrites.

But these long lines of fracture are not often marked by any consolidated filling. The conditions near the surface may not have been favorable to the formation of such a filling, and many of these fractures are perhaps too recent to have allowed of sufficient time for this process to have taken place. Close to these lines the rock all along is broken into small pieces, which however have been only slightly moved from their original sites; but as we recede from the lines of crushing the angular pieces become larger and larger till the whole rock has resumed its normal solidity.

This broken condition has permitted the percolation of the surface waters to great depths, which has been followed by the decay of the fractured rocks more or less rapidly in proportion to the fineness of the pieces into which they have been crushed. The joints for some distance on either side of these lines are stained with the oxide of iron, resulting from the general decomposition.

The disintegration of the rock on such lines, as well as that of the greenstone dykes, has caused valleys to be formed along them as the result of glacial and other eroding agencies. In the district under consideration the writer in referring to this subject in 1876 said:

> "Between the mouth of the Maganetawan river and the first fall, especially along the north side, the gneiss, which runs in various directions, is of a dry, crumbling character along a set of joints which run parallel to the stream and are lined with oxide of iron. The course of Byng inlet and of the Maganetawan river (in continuation of it) is remarkable for being comparatively straight and crossing the general course of the gneiss and mica and hornblende schists, as well as that of the lakes and the numerous smaller streams of the district. This would appear to indicate that the formation of this channel has had something to do with the existence of the brecciated dykes or the joints above described."*

Lines of crushing in the Laurentian rocks were seen by the writer in some of the precipices in Hudson strait, where they were observed traversing walls of gneiss, and were well marked by the crumbled gneiss, still quite fresh.

Transverse depressions or gaps in crystalline rocks have also been formed in the following manner: The parallel joints which so frequently traverse granite, gneiss, quartzite, etc., are apt at intervals to occur in groups closer together than usual, or two or three may run side by side, which are stronger and more persistent than the single ones and comparatively distant from the nearest of them. The narrow walls of rock between such joints have suffered decay or injury from the surface influences in pre-glacial times, and, yielding to erosion more easily than the rest, have formed the starting lines of depressions and valleys. This phenomenon was referred to in connection with the erosion of water-channels in the French river region, and it may also be observed in various rocks in other parts of our district.

Two sets of nearly vertical joints often traverse crystalline rocks at angles approaching 80° or 90° to each other. When such rocks are cut by a third set almost horizontally they are then divided into rhombohedral blocks, and are much more easily removed by abrading and disintegrating forces. It not unfrequently happens, as in the case of some granites, that there may be four sets of joints, thickly penetrating the rock and dividing it into comparatively small triangular pieces. This imparts a shattered character to the whole mass, and renders it useless for building or monumental purposes. Some masses of granite have been saved from the forces which produced these numerous joints or cracks, apparently by the protection afforded by yielding belts of schist. At all events the more solid and serviceable granites are often thus sheltered.

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*Report of the Geological Survey for 1876-7, p. 202.

CRYSTALLINE SCHISTS.

The Huronian system comprises a great variety of crystalline schists in both the lake Huron and lake Superior regions. In the latter the older portions of the series are to a great extent formed of mica, hornblende, diorite and chlorite schists, while these and other varieties of schists are interstratified with different rocks higher up in the scale. In the Sudbury district the northwestern border of the Huronian belt in the townships of Waters, McKim and Blezard is largely made up of crystalline schists, of which dioritic, hornblendic, silicious and felsitic are the most abundant. Further to the northeast similar schists are abundant on lake Temagami. Silicious and felsitic schists are largely developed between lake Wahnapitae and the line of the Canadian Pacific Railway. Coarsely crystalline hornblende rock, such as is found among the Huronian strata of lake Superior, has been met with just east of the Stobie mine in Blezard, in the fifth concession of McKim, and near the McConnell mine in the fourth concession of Snider; also at the southwest bend of Spanish river and at Lamorandiere bay in the northwest corner of Rutherford. Green schists, schistose greywacke and gneissoid schist, the latter enclosing boulders, occur among the rocks of the Straight lake Huronian outlier.

In illustration of the mode of occurrence of crystalline schists among the Huronian rocks of the lake Huron region, the following examples on the Spanish river are selected from the descriptions in the report of the writer for 1888-90.

Half a mile up the west branch of this river a rock was met with which consisted of a mixture of green schist and fragments of granite. At the bend of this branch, four miles from the main stream, there was found what Professor Williams describes as a "pinkish to brownish crypto-crystalline banded rock, which might be macroscopically described as a banded jasper or felsite. The microscope shows that it is a clastic rock, consisting mostly of quartz which has been wholly re-crystallized under the influence of intense pressure, and that it has thus had the parallel structure developed in it by an elongation of its grains in one direction that is commonly known as stretched."

On lot 1, sixth concession of Baldwin, just below a large island in Spanish river, the rocks in the bed of the stream consist of fine-grained pink quartzite in thin layers, interstratified with rough-surfaced black slate, dipping southward at a high angle, while at a greater elevation there is exposed a heavy band of dark green mica-schist formimg the top of a long ridge.

At the narrows of the river, on the east side of lot 12, first concession of Hyman, there is a coarse gray glistening schist and a small quantity of a dark greenstone. Below the narrows, on the next lot (11 in the same concession) a glossy dark bluish grey schist and a slaty greywacke strike northeast along the flank of a mass of diabase which has a length of more than a mile in a northeasterly direction. A fine-grained hornblende rock also occurs at this locality. In the same vicinity, where the line between lots 10 and 11 intersects the north bank of the river, quartzite occurs dipping south at an angle of 55°.

In the northwest corner of lot 8, first concession of Hyman, there is a chute in the Spanish river with a fall of 15 feet. At this locality there is an extensive exposure of rather fine-grained silver-gray mica-schist with crystals of staurolite, thickly scattered over the cleavage surfaces.

In the middle of lot 5, second concession of Hyman, the river passes through a cañon or narrows, with gray schist on the northern side, and the northern flank of a ridge of fine-grained splintery greenstone running north 70° east on the southern. At a rapid in the north half of lot 3 in the same concession, a bluish gray satiny schist strikes due north and south, the dip being east at an angle of 45°. This sudden change in the strike is accompanied by an equally sudden turn in the course of the river.

The rocks at Kettle falls, on lot 2, second concession of Hyman, are gray and satiny schists with a three feet band of nearly black hornblende schist, all striking north 76° east, with a southerly dip of 75°. On the line between lots 2 and 1, first concession of the same township, and opposite the west end of an island in the river, the rock is a glossy gray, finely-arenaceous schist nearly on edge and striking north 85° west. A gray glistening schist, standing vertically and striking north 75° east, occurs at the falls on the south side of the island.

A soft bluish-gray schist striking eastward with the course of the river is found on lot 11, first concession; and on the northeast corner of lot 9 there is a glossy green schist, but without strong cleavage.

A gray hydro-mica schist running southwest occurs where the Canadian Pacific Railway crosses the Spanish river, in the centre of lot 11, second concession of Nairn.

SERPENTINE, STEATITE AND DOLOMITE.

These three kinds of rocks may be mentioned among those which occur in minor volume in the Huronian system. Serpentine has not yet been found at all within our present region, but some exposures of it were met with at Pigeon lake on the west branch of Montreal river, a short distance to the northward. The serpentine occurs by itself, or associated with calcspar, or passing into limestone, on some small islands in this lake.

On the shores in the vicinity are fine-grained and massive reddish-gray quartzite, greenish-gray clay-slate, fine-grained reddish-gray syenite, light greenish-gray finely crystalline diorite, with disseminated grains of iron pyrites and gray porphyry very thickly speckled with opaque-white crystals of felspar and a few of shining black hornblende. The serpentine on fresh fracture shows different shades of green, and is somewhat mottled. Under the weather the natural surface becomes rough and of a rusty color. It contains oxide of chromium, both in the form of small grains and in chemical combination with the rest of the rock, and thus resembles the serpentines of the Eastern Townships in the province of Quebec. The writer has been shown specimens of serpentine said to have been collected among the Huronian rocks some miles north of Pigeon lake. On the point about the middle of the west shore of Abittibi lake the late Mr. Walter McOuat of the Geological Survey met with dark green serpentine, weathering dull white, strongly magnetic and containing grains of chromic iron. Mr. E. B. Borron informed the writer that he had heard of serpentine having been found in the country lying north of the west end of Abittibi lake.

On the Mattagami river, thirty chains below the junction of the Muskoota branch, there is an exposure of massive gray semi-crystalline steatitic rock, holding grains of specular iron and cut by small veins of whitish bitter-spar. Although this locality, as well as those for serpentine which have been mentioned, are outside of the limits of our sheet, both of the rocks referred to above may be looked for wherever similar rock associations exist within this area. The greenstone of the Evans mine, near Sudbury, has changed in some parts into a variety of steatite or soapstone.

Dolomites or magnesian limestones, having certain characters in common, occur sparingly in the Huronian system in the most widely separated areas of these rocks. They are usually fine grained to compact, silicious and marked by strings and fine threads of quartz and sometimes of calcspar, which have commonly a reticulating arrangement. Most of them are ferruginous, and the weathered surface is generally yellow, brown or red, but sometimes gray or black. The iron is often present in large enough proportion to form a spongy crust of the oxide. Occasionally these dolomites become rather finely crystalline, like saccharoidal marble, and nearly white. In our present region they have never been traced far on the strike, although they attain from 100 to 300 feet in thickness.

Midway up the northeast side of Pigeon lake, already mentioned, on the west branch of Montreal river, there is a bluff thirty feet high of semi-crystalline, yellowish-gray limestone, mottled with green and reddish-brown patches and full of reticulating strings of white calcspar. The weathered surface has a ferruginous crust, from one-half to one inch thick, showing the rock to contain a large proportion of iron. A thickness of upwards of one hundred feet of the limestone is exposed at this place, and it continues northward along the shore for a quarter of a mile or more. The other rocks in the vicinity of this dolomite consist of syenite, diorite, serpentine, porphyry and different varieties of quartzite.

On the eastern side of South bay, lake Wahnapitae, and thence round the promontory towards Outlet bay, Mr. Alexander Murray described a calcareous breccia associated with quartzites and greenstones.*

In Geneva lake, about a mile and a-half northeast of the outlet, there is an islet entirely composed of thinly bedded light gray, dove-colored and nearly white dolomite, striking north 35° east, and dipping to the westward side at an angle of 80°. It is compact and has a conchoidal fracture, but is traversed by fine threads of quartz, which prevent it from taking a good polish, otherwise it might be suitable for marble. The same rock is exposed on the east side of the lake on the point just southward of the above islet, but the band could not be found on the northern side of the lake, towards which it strikes in the opposite direction. On the railway track three-quarters of a mile south of the outlet of Geneva lake there is a fifteen-feet bed of gray to dove-colored fine-grained dolomite, weathering dark brown. It strikes north 45° east, and the bedding is about vertical. This dolomite band is separated from hornblende granite to the southeast by about three hundred feet of ash-gray greywacke. The granite towards its contact with the latter becomes mixed with coarse breccia and conglomerate. On the other side, or to the northwestward, the dolomite is followed by coarse felspathic sandstone and silicious greywacke-conglomerate or breccia. At the outlet of Geneva lake the rock is a greywacke passing into granite, and it includes some black slate and a patch thirty feet thick of impure dolomite.

A band of magnesian limestone occurs at Island Portage on Wahnapitae river, about four miles below the outlet of the lake of the same name. It has a width of at least 300 feet across its general strike, but owing to the undulation of the strata the true thickness of the band could not be determined. On fresh fracture it is mostly light greenish-gray in color, fine grained, soft, somewhat impure, and weathers to a brown color. The weathered surface in some parts is marked by small corrugated ridges, like that of the Huronian limestone of Echo lake, which result from the weathering out of minute silicious streaks following the bedding. An exposure of the limestone at the head of Island Portage shows a more massive variety with a brownish gray color on fresh fracture.†

Referring to the magnesian limestones of lake Panache Mr. Alexander Murray says:

> On the north shore of lake Panache, about midway between the inlet from lake Lavase and its western extremity, a band of limestone occurs which when first observed appears to be both underlaid and overlaid by syenitic slate-conglomerate. The mass of this limestone, which measures about sixty yards across and may be about 150 feet thick, is of a pale gray color on fracture, weathering to a bluish gray, with thin layers which have the appearance of chert, but are in reality only harder portions of the limestone, weathering quite black. About the base of the calcareous strata some of the beds are blue, holding more silicious matter than the gray beds, while others are of a brecciated character. The beds are all more or less intersected by small veins of fine greenish jaspery-looking trap which weathers brown or yellowish.
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> To the eastward of this exposure the only indications observed of the presence of limestone were on the east side of the large island at the entrance of the south bay, and in the peninsula on the north side at the entrance of the eastern arm; in both of these localities small exposures of a black-weathering brecciated rock, which proved to be calcareous, came up in one or two parts just over the surface of the water. On the island the calcareous rock is overlaid by a black-weathering slate which, though without pebbles, resembles the matrix of portions of the slate-conglomerate. On the peninsula at the eastern arm the brecciated rock comes directly in contact with greenstone.
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> At the head of the lower south expansion of lake Panache the limestones are again seen on both sides, and also on the two islands near the middle, striking about east by

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* Report of the Geological Survey for 1856, p. 177.

†Report of the Geological Survey for 1875, p. 296.

north and west by south, and showing a southerly dip on the north side of the exposures; but the slate conglomerate with which it seemed to be associated at other parts only appears on the south side of the large island lying at the entrance to the northern army and between this island and the exposure of limestone on the west side of the bay there is a point to the northeast of the limestone displaying fine-grained green slate which, though very much disturbed and intersected by quartz veins, appears to show a general dip to the northwest.*

Mr. Murray thinks that some of the above strata might yield good stone for burning into lime. A specimen from the section on the north side of lake Panache was analysed by Dr. T. Sterry Hunt, and gave in 100 parts 55.10 carbonate of lime, 6.50 carbonate of magnesia, 38.40 insoluble sand and a trace of iron. A specimen of the limestone at the lower end of lake Panache, analysed by the same chemist, gave 41.97 per cent. carbonate of lime, 2 40 carbonate of magnesia and 55.63 insoluble residue; and a specimen from the lower lake near the outlet, lying between the two ridges of the mountain range, gave 36.50 per cent. carbonate of lime with a little magnesia.†

Along the northern arm of the larger La Cloche lake calcareous rocks or impure limestones occur at several places passing below a considerable thickness of slate conglomerate, and they are again met with on the smaller lake to the northwest. High ridges of quartzite, standing nearly on edge and forming part of the La Cloche mountains, rise on either side of the southern arm of the larger lake, while greenstone and quartzite are found on the northern side of the smaller one. It would therefore appear that in this part of the great Huronian belt the magnesian limestones occur among the quartzites, and are sometimes more immediately associated with slate-conglomerate.

A band of finely crystalline limestone occurs among the Huronian rocks in the northern part of the township of Rutherford. The locality is near the boundary line between red granite to the southward and a great thickness of quartzites to the northward. The junction of the granite to the southeast with the Huronian quartzite and hornblende schists to the northwest occurs at the south side of a rather elevated rocky island in a cove about one mile north of the western entrance to "the passage" or channel, on the north side of which Killarney village is built. The geology of this locality and the relations of the limestone referred to can best be given by quoting the description in the Geological Survey report by the writer for 1876, page 209:

> On the west side of the township of Rutherford, from the northern limit of the granite (at the elevated rocky island above mentioned) quartzites and hornblende schists hold the shore as far as Lamorandiere bay, in the northwest corner of the township. A blackish green massive and rather coarsely crystalline hornblende-rock, having an exceedingly rough or irregularly pitted surface, is exposed on either side of the narrow entrance to this bay. Upon the slope of the hill, about 100 yards in from the north shore of the bay, at a point about half-a-mile from the above-named narrows, a band of finely-crystalline limestone occurs among the Huronian rocks. It has a vertical attitude and runs about north 70° west at the part examined. Its total thickness is about 75 feet, of which the 25 feet along the northern side consist of a single solid band of nearly white finely-crystalline limestone, clouded with light greenish and grayish patches. The remaining 50 feet are mixed with shaly patches of hornblende, together with a little shining granular magnetic iron ore. Adjoining the limestone on the north side is a band, only a few feet in thickness, of dark smoke-colored chert-rock, ribboned with streaks of a dull red color. It breaks easily with a fine conchoidal fracture, and appears to be identical with a rock which was used by the mound-builders for making some of their arrow-heads. This is followed to the northward by a dark-colored dioritic conglomerate, in which the pebbles are mostly small and generally widely scattered, and farther on by a very dark gray, soft massive-looking micaceous schist, most of which is full of small pebbles. Measured from the limestone band, a thickness of between 100 and 200 feet of these rocks is exposed.
>
> On the north shore of Lamorandiere bay, a few hundred yards eastward from the outcrop of limestone above described, are two exposures of very tough massive hornblende rock, and between the two arms of the bay is a more fissile variety, interstratified with a reddish gray quartzite, which also overlies the mixed rocks. The dip is here northwestward at an angle of 60° to 70°, and the series is underlain by granitoid gneiss.

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*Report Geological Survey for 1856, pp. 181-183. †*Ib.* p. 190.

INTRUSIVE GRANITES.

The red granite of George island and the township of Rutherford may be of intrusive origin, notwithstanding that it shows an approach to lamination towards the edges of the mass. "Its position is along the junction of the Laurentian with the Huronian series, and it appears to belong to the latter rather than the former. It has a medium texture, and is composed of reddish felspar and bluish-white quartz with a little hornblende, which however is often wanting. Excepting at the sides it has a massive homogeneous structure, but in a few instances a single reddish or yellowish-green shaly streak, an inch or two in thickness, was observed running in a northeasterly direction with a dip to the southeastward of about 50°. Towards each side the grain of the rock begins to assume a sort of parallelism or a gnessoid structure."*

Reference has already been made to an area of red granite measuring about four miles in length by two in breadth between the western and middle outlets of French river, and also to a brick-red granite or syenite along the upper part of the lower north channel of that river just below Grand Recollet falls.

Red granitic rocks border the newer ones which lie to the south of them all the way from the township of Cascaden to lake Wahnapitae. Although the macroscopic appearance of these rocks is that of a red granite, yet in some parts, as on the east side of Windy lake, the textural arrangement of the component minerals is more like that of a quartz-diorite, and they are certainly of eruptive origin. Professor George H. Williams examined under the microscope a thin slice of a fine grained variety of these rocks from Kin-ni-wabik lake in the township of Levack. He pronounced it micropegmatite, and stated that it was an undoubted eruptive. Towards lake Wahnapitae similar rocks continue to be fine grained, but in that direction they become dark grayish-red in color. Around Washai-gamog or Fairbank lake the rocks have a similar color and texture to the last, and their appearance is the same except that they are distinctly stratified and occur in very even beds. The granitoid rocks above described merge into gneiss at varying but not great distances to the northward.

About a mile east of the angle formed by the intersection of Proudfoot's east-and-west with his north-and-south line red hornblende granite was found. Its extent has not been ascertained, but it may continue a considerable distance northward.

A Laurentian inlier has been mentioned as occurring around Paul's lake on the upper part of Sturgeon river. Where first entered upon in ascending the river at four miles below the lake the rock of this inlier consists of a rather coarse dull red quartz-syenite, or hornblende granite, but this passes into gneiss before the lake is reached. An area of coarse red granite crosses lake Temiscaming about the middle.

GENERAL NATURE OF THE HURONIAN ROCKS.

While the greater portion of the Huronian rocks show the agency of water in their formation, there is also abundant evidence of widespread contemporaneous volcanic action. These detrital or clastic sediments were largely derived from igneous matter which had been more or less recently erupted, and hence they may be called pyroclastic, as indicating both phases of their nature. Besides rocks of this character, we have seen that the Huronian system contains large igneous or crystalline masses. The whole series having been considerably metamorphosed, the true origin of some portions may not be at first apparent. But our study of them on a large scale in the field as well as the microscopic examination of hand specimens go to show that the above is the general nature of the Huronian rocks in all the areas which have been explored. The pebbles and boulders of the conglomerates of the Huronian system consist of binary-granite, schists, quartzite, white quartz and red jaspar, greenstone, gneiss and other rocks derived from older parts of the same series or from the underlying Laurentian.

The presence of these conglomerates and the ripple-marks which are sometimes plainly seen on the surfaces of beds of quartzite prove the existence in those days of either dry land or of seas which were very shallow in some places. The limestones or dolomites are only of local extent. They are sometimes nearly pure, or, as we have seen, they may be largely mixed with insoluble matter, or they may be brecciated with silicious fragments. The lime and magnesia may have been derived from the decomposition of the pyroxene and hornblende of the greenstones. Some of the masses may be of a segregated or a concretionary character, while others were precipitated from water.

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*Dr. Bell in Report of Geological Survey for 1876, p. 208.

NEWEST ROCKS OF THE SUDBURY DISTRICT.

The newest rocks of the Sudbury district form a distinct basin extending from near the west side of lake Wahnapitae southwest to about the centre of the township of Trill, a distance of thirty-six miles, with a breadth of eight miles in the centre. This basin constitutes a prominent feature in the geology of the district, and it may prove to be of lower Cambrian age. Along its northern side it is bounded by the granitoid rocks already described, and on its southern by a belt of Huronian schists and greywacke. The rocks of the basin consist of two principal divisions,—(1) the lowest being a band, probably three or four thousand feet thick, of dark colored or almost black silicious volcanic breccia or vitrophyre tuff, most strongly developed along the northern side and passing into black slate and black slate-conglomerate along the southern; and (2) drab and dark gray argillaceous and nearly black gritty sandstones with shaly bands which vary in color from greenish drab to black. At the base of the volcanic breccia a conglomerate consisting of a grey silicious matrix with rounded white quartz pebbles is seen in some places, but this may belong to the underlying series.

The area of this geological basin corresponds in a striking manner with certain well marked physical and geographical features. The volcanic breccia forms a range of hills more conspicuous and rugged than any others in the district, while the sandstones and shales constitute a low and nearly level tract from which lakes, elsewhere so common, are absent. The Vermilion river flows southwestward with the strike all along the northern side of this division, and Whitson creek flows in the same direction along the southern side.

The silicified glass-breccia or vitrophyre tuff maintains the same character and apparently about the same thickness all the way from the vicinity of lake Wahnapitae to the township of Trill. It occurs in massive form and falls from cliffs or ridges in large blocks. It breaks with a conchoidal fracture, and when fresh is seen to be made up of angular fragments, mostly small and closely crowded together and flecked with irregular white spots. The fragments are not so dark as the matrix, and present various shades. When examined with a lens many of the fragments show a distinct vesicular structure. Prof. George H. Williams has examined this breccia carefully both in hand specimens and under the microscope, and says that it is "composed of sharply angular fragments of volcanic glass and pumice, which, in spite of almost complete silicification, still preserve every detail of their original form and microlithic flow-structure with a distinctness not to be exceeded by the most recent productions of this kind . . The fragments even down to those of the smallest dimensions have the angular form characteristic of glass shreds produced by explosive eruptions. The flow-structure is as perfectly marked by sinuous lines of globulites and microlites, which terminate abruptly against the broken edges of the glass particles as in the most recent vitrophyre. Minute spots of opaque pyrrhotite are scattered through the section. The groundmass is of a dark color, owing to the massing in it of minute black globulites, to whose nature the highest magnifying power gives no clue . . . After a careful study of this rock I find it possible only to interpret it as a remarkable instance of a very ancient volcanic glass-breccia, preserved through the lucky accident of silicification. Nor did this process go on as is usual through devitrification and loss of structure, but rather like the gradual replacement of many silicified woods, whose every minute detail of structure is preserved. The rarity of such rocks in the earth's oldest formations is readily intelligible; but, for this very reason, the exceptional preservation of a rock like this is all the more welcome proof that explosive volcanic activity took place at the surface then as now, and on a scale if possible even greater than that with which we are familiar."*

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*Bulletins of the Geological Society of America, 1890, pp. 138-40.

A fresh section of this rock is exposed in a cutting on the Canadian Pacific Railway at the high falls of Onaping river, twenty miles northwest of Sudbury Junction. An analysis of an average specimen from this place was made by Mr. Hoffmann of the Geological Survey, and it was found to contain 60.23 per cent. of silica. A smoothed surface of this dark rock has a handsome appearance, but it is incapable of a high polish.

The dark argillaceous sandstones and drab and dark shales of the higher division of the rocks of this newer basin may be seen at all the southward bends of the Vermilion river from Onwatin lake nearly to Vermilion lake. The strike corresponds with the general course of the river, and the dip is southeastward at rather high angles. The sandstones are characterized by disseminated grains of transparent quartz, and they often hold rounded or ovate spots from an inch or two up to three feet in diameter, of a lighter color than the rest of the rock. On exposed surfaces these spots weather into depressions. Several parallel ridges of this sandstone with a northeasterly course cross the Canadian Pacific Railway line diagonally between Larchwood and Chelmsford. It appears to be well suited for building purposes. This sandstone, both as regards the spots just described and its dark color and massive character, bears a strong resemblence to the silicious rocks which, in the form of boulders and smaller pieces, are scattered so abundantly around the shores of James bay and over the country for a great distance to the southwest of it. A similar rock is found in place on Long island on the east coast, and at Churchill on the west coast of Hudson bay, and there are reasons for believing that it is very extensively developed on the floor of that sea.

LOWER SILURIAN OR ORDIVICIAN SYSTEM.

The islands of the La Cloche group and the peninsula of the same name in the southwestern corner of our sheet consist of flat-lying fossiliferous rocks of the Lower Silurian or Ordivician system, with some ridges and knobs of Huronian quartzite protruding through them. The middle portion, which constitutes the bulk of this group, is made up principally of rather thinly-bedded, lumpy and uneven surfaced gray limestones, with many thin, shaly beds and partings interstratifying them. But underlying these measures are from 50 to 100 feet, or perhaps more, of reddish and chocolate colored calcareous marls with greenish layers and mottlings, togethor with some beds of fine grained white and reddish sandstones, while overlying them and interstratifying the upper portion are beds of hard, compact, dark gray magnesian limestone, which weathers to various yellowish and reddish shades.

The lower or marly and arenaceous portion of the series has yielded no fossils by which its age can be identified, but it is believed to represent some formation older than the Trenton group, and it was thought by Logan that it might be the equivalent of the Sault Ste. Marie sandstones, which he considered to be Chazy, but which are referred to the Potsdam formation by the United States geologists.

The upper beds of the Trenton group are seen at the north end of Strawberry island, and in the north-facing bank at Little Current at the northern extremity of Manitoulin island. At these localities they are overlaid by the black bituminous shales of the Utica formation. The breadth across the strike from the north side of La Cloche island to the commencement of the Utica shales on Strawberry island is eight miles. The average dip to the south is assumed to be 40 feet in the mile, so that the total thickness of the Trenton group would be about 320 feet. The fossils which have been collected among these rocks from the summit of the marly and arenaceous portion up to the highest beds on La Cloche island, and also from the islands just west of the latter, belong to the Birdseye and Black River divisions of this group, so that the Trenton formation proper in this region is confined to a strip bordering the shore for six miles in the neighborhood of Little Current and thence round into West bay, the northern part of Strawberry island and the peninsula between Manitowaning and Smith bays. On Heywood or Rat island, along with a little Utica shale there is some limestone which appears to belong to the Trenton formation. Patches and margins of fossiliferous gray limestones resting on the quartzite and dipping into the lake are found here and there along the high point which runs from Killarney bay towards Heywood island and on the islands just south of it. These rocks appear to be identical with those forming the central part of La Cloche island, and they would therefore belong to the Birdseye or Black River formation.

As already stated, the black shales of the Utica formation rest upon the top of the Trenton limestones in the village of Little Current and cover the greater part of Strawberry island. They are found near the quartzite ridge at Sheguiandah village, also at the base of the Hudson River formation between Manitowaning and Smith bays, and in a similar position at cape Smith.

ECONOMIC MINERALS.

Only a small part of the district represented on the accompanying map has yet been explored for useful minerals, but the discoveries already made are sufficiently numerous and important to lead to the belief that a promising future is in store for this part of Canada as a mining region. The metallic ores appear to be confined to the Huronian rocks, which are here so extensively developed. The Sudbury district has become well known for its extensive nickeliferous deposits, and prospecting has been as yet confined chiefly to that region. Ores of several other metals have also been found in the district, and the indications are in favor of meeting with some of them in paying quantities. What has been accomplished in the Sudbury district may be repeated in various parts of the great unexplored Huronian belt to the northeastward.

But the useful minerals of our present region do not consist entirely of metallic ores. The non-metallic mineral products, such as building and ornamental stones, rock for lime and glass-making, etc., are also important. Some of these occur among the Laurentian and others among the Huronian rocks. As the district is only beginning to be inhabited, and the need of such materials has scarcely been felt, little or no effort to find them has yet been made; but as soon as there is any demand they will no doubt be found in many new localities. The possibility of discovering workable deposits of phosphate of lime among the Laurentian rocks of the district, and of asbestos along with the Huronian serpentines, as well as of other substances usually found among these rocks, should be borne in mind.

IRON.

Among the quartzites of the La Cloche region small isolated deposits of magnetite and one or two of hematite have been found, but none of those yet discovered appear to be sufficiently extensive to justify mining operations. From analyses reported to have been made of the ores from two or three of these deposits they would appear to be sufficiently free from titanium, phosphorus and sulphur to constitute first-class ores. It is to be hoped that further explorations among these rocks may bring to light larger masses of iron ore.

Thin veins of good magnetite, accompanied by quartz, occur in the red hornblende-granite two miles north-northwest of Cartier station, and again in the same rock on the Spanish river a short distance below The Elbow. But the granitic districts do not appear to be promising for the ores of iron.

The existence of iron ore on Iron island in lake Nipissing is only known to most of those interested in the minerals of the district by vague report. It may therefore be worth while to quote the description of it given by the late Alexander Murray of the Geological Survey.

> Small masses of specular iron ore are common to most of the rock in the island, and in the crystalline limestone there is a very great display of it. For a breadth of about forty yards along the cliff on the east side the rock holds masses of the ore of various sizes, sometimes running in strings of an inch thick or upwards and at other times accumulating in huge lumps, some of which probably weigh over half a ton. The beach near the outcrop is strewn with masses of all sizes, from great boulders weighing several hundred pounds to small rounded pebbles not bigger than marbles. The limestone with which the

ore is associated is frequently cavernous, and the crevices and small fissures are thickly lined with crystals of blue fluor-spar and red sulphate of baryta or cockscomb-spar.

Crystalline limestone crops out on the opposite or west side of the island and, judging by the strike on the north side, it must correspond with that holding the iron ore on the east. The same minerals were found disseminated through the rock and strewn upon the beach. At the extreme southwest point of the island the rock is again crystalline limestone, and a long beach running out from it to the westward is perfectly covered with boulders of specular iron ore. Iron ore occurs also at the southeast point of the island, although not in such great abundance and only in detached masses strewn upon the beach.*

In the Huronian iron-bearing region of lake Superior the ores have two different sets of associations or modes of occurrence. In the one case they are associated with hornblendic or chloritic schists which appear to belong near the base of the system, and in the other they occur with fine grained silicious and jaspery rocks. The magnetite of the Atik-okan region is an example of the first, and that of Hunter's island and Kaministiquia river of the second.

NICKEL.

The comparatively recent discovery of workable deposits of mixed copper pyrites and nickeliferous pyrrhotite over a large area in the Sudbury district is one of the most important events in the history of mining in Canada. Although masses of pyrrhotite are known to exist in other parts of the Dominion, there is no other region where they are so numerous and in such proximity to one another, and with the exception of one near St. Stephen in New Brunswick they do not appear to be nickeliferous to an economic degree, whereas in Sudbury district all the deposits so far tested are comparatively rich in nickel. The pyrrhotite of this region is found in the midst of rocks of different characters and belonging to different horizons, but it is always more immediately accompanied by greenstone. Indeed this rock may be regarded as the parent of the ore. These facts would seem to indicate that in the Sudbury region the greenstone had a common and deep seated origin. The area over which the ore has been discovered is of an eliptical form, and measures about 70 miles from southwest to northeast and 50 miles from southeast to northwest.

The first discovery of nickel in this region was made about 1846, at the Wallace mine in Bay of Islands on the north shore of lake Huron, about a mile west of the mouth of Whitefish river. This mine was opened in 1847 and was visited in 1848 by the late Alexander Murray of the Geological Survey, but at that time mining operations had been temporarily suspended. The ore consists of chalcopyrite with magnetic and arsenical pyrites rich in nickel, occurring in chloritic and quartzose schists close to a mass of greenstone. The extent of the deposit cannot at present be seen on account of the debris on the surface and the shaft being full of water. Mr. Murray in his report says:

> The temporary condition of the mine at the period of our visit rendered it impossible to obtain such specimens as might be considered an average sample of the material excavated from the shaft; but with a view of ascertaining the quality of the nickeliferous portion of the ore a specimen of it, as free as possible from the copper pyrites, was submitted to analysis by Mr. Hunt, who found it to contain 8.26 per cent. of nickel with a trace of cobalt; but as nearly two-fifths of the specimen consisted of earthy materials which might readily be separated by dressing, the quantity of nickel in the pure ore which this would represent would equal nearly 14 per cent.†

The existence of nickel and copper in the greenstones of what is now the Sudbury district was first made known by Dr. T. S. Hunt and Mr. Alexander Murray of the Geological Survey in 1856. In that year Mr. Murray explored Salter's base line, running northward from Whitefish lake, and in what is now the township of Waters he found a mass of magnetic trap which proved to contain disseminated nickel and copper. He says:

> Specimens of this trap have been given to Mr. Hunt for analysis and the result of his investigation shows that it contains magnetic iron ore and magnetic iron pyrites generally disseminated through the rock, the former in very small grains; titaniferous iron was found associated with the magnetic ore and a small quantity of nickel and copper with the pyrites.‡

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*Report of Progress for 1854, page 123.

†Geological Survey Report for 1848, p. 44.

‡Report of the Geological Survey for 1856, p. 180.

Again referring to this subject Mr. Murray says:

The magnetic trap discovered on Mr. Salter's meridian line north of Whitefish lake was observed to hold yellow sulphuret of copper occasionally; and Mr. Hunt's analysis of a hand-specimen of the rock, weighing ten ounces, gave twenty grains of metalliferous material, of which eleven were magnetic and consisted of magnetic iron ore, with a little titaniferous iron ore, and magnetic iron pyrites containing traces of nickel. The nine grains of non-magnetic mineral consisted of iron pyrites, containing from two to three per cent. of copper and about one per cent. of nickel. Many large quartz veins occur on the lower lakes of the Whitefish river, but iron pyrites was the only metalliferous substance which they were observed to contain.*

In constructing the Canadian Pacific Railway line in 1882 the mass of ore which is now being developed as the Murray mine, three miles and a half northwest of Sudbury Junction, was cut through at the surface. This discovery was followed in 1883 by the finding of ore at what are now the Stobie, Copper-cliff, McConnell and other mines in the neighborhood. These occurrences were at first regarded as of value only for the copper which they might contain, and, notwithstanding that the existence of nickel among the associated rocks of the region had been pointed out by Murray and Hunt so long before, it was not till three or four years after the above discoveries had been made and a thousand tons of dressed ore had been sent to England from the Copper-cliff mine that the value of the ores for nickel was recognized.

The ore is very much the same at all the occurrences in the Sudbury district. It consists of a mixture of nickeliferous pyrrhotite or magnetic pyrites, with more or less chalcopyrite or copper pyrites. The larger ore-masses generally approach lenticular forms, with their longer diameters parallel to the strike or to the line of junction of the enclosing rocks. Their attitude is usually nearly perpendicular, the dip or underlie being sometimes apparently at higher angles than those of the adjacent rocks.

Each of the larger ore-bodies is made up of a brecciated or a conglomerate-like mixture of the above-mentioned sulphides and the country rocks next to it, the fragments of the latter varying in dimensions from mere grains and very small pieces up to immense boulders, but the average size is a few inches in diameter. In some cases the stony fragments constitute so large a proportion of the mass that they come almost into contact with each other, the interspaces being filled with the sulphides, while in others there are considerable bodies of nearly pure ore with only occasional rocky fragments scattered through them. In a few instances a granitoid filling between the fragments takes the place of the sulphides. A good example of this may be seen at an opening in one of these ore-masses on lot 3, fifth concession in the township of Levack.

The usual site of these ore bodies is at the junction of greenstone with some other rock, especially granite, gneiss or felsite. Another circumstance which appears to have influenced the localization of the ore is the intersection of the ore-bearing planes by one of the dykes which have been described, or by a throw, or a number of minor dislocations. The existence of one or other of these conditions has been noticed at or near most of the larger ore-bodies of the district.

These deposits have not yet been worked to a sufficient extent to prove much in regard to their persistence or otherwise, in depth. The Copper-cliff mine however has been already wrought to a depth considerably greater than the horizontal length of the ore-mass, either on the surface or in any of the levels. Ore deposits of a similar character in other parts of the world have sometimes proved on working to possess a much greater depth than horizontal measurement. In the absence of any indications to the contrary, it may therefore be expected that the nickeliferous deposits of the Sudbury region will prove equal in depth to their horizontal extensions.

As to the genesis of the ore bodies, the evidence points to their origin from a state of fusion. The fact that the ores always accompany the greenstone (itself of igneous origin) is a strong proof of this supposition. These sulphides fuse at about the same temperature as the greenstone, and in the cooling of the latter they would naturally tend to coalesce in small and large masses. The dissemination of both the chalcopyrite and the pyrrhotite so generally throughout the whole mass of the commoner varieties of the greenstones, and the rich impregnation of these rocks with the same sulphides in the vicinity of the ore bodies, are additional evidence in the same direction. In the isolated kernels of ore, often scattered so thickly through the greenstone in the vicinity of the workable deposits, we find groups consisting of either of the sulphides, separately or intermingled, and often the individual kernels will be made up of the two kinds mixed together. These kernels, together with larger patches of the ores, constitute every proportion of the rock, from a small percentage up to half the total weight or more, when the mass has become sufficiently rich to put upon the roast heaps. In the mixed sulphides of these ore bodies the pyrrhotite generally contains a certain proportion of disseminated grains of quartz and other stony matter, while the chalcopyrite is usually tolerably pure. This may be owing to the manner in which the latter separated itself from the former, whether in a state of fusion or by some subsequent process. Although most of these ores appear to have separated themselves from a cooling magma, we find occasionally evidence of subsequent modifying processes. Still there can be little doubt that the larger ore bodies of this district were not originally deposited from aqueous solution like the gangue and ore of ordinary metalliferous veins.

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* Report of the Geological Survey for 1886, p. 189.

The above ores do not contain a very high percentage of nickel or copper, their value depending more on their abundance and the facility with which they can be mined than on their richness. The Canadian Copper Company, after having smelted thousands of tons of the ores from the Copper-cliff, Evans and Stobie mines, found the average yield of nickel for the year 1890, to have been 3.52 per cent. and of copper 4.32 per cent. The ore smelted at the Blezard mine up to March, 1891, averaged 4 per cent. of nickel and 2 per cent. of copper; that smelted at the Murray mine up to the same period averaged 1.5 per cent. of nickel and 0.75 per cent. of copper. Mr. F. L. Sperry, late chemist to the Canadian Copper Company, found the average of nine assays of ores from the mines of his company to be 2.38 per cent. of nickel and 6.44 of copper. Assays of eleven samples of the ores of the district made under the supervision of Mr. Hoffmann, chemist to the Geological Survey, gave an average of 1.69 per cent. of nickel. The average of all the above smeltings and assays gives us 2.62 per cent. of nickel, which may be taken as the general average of the ores of the Sudbury district. Exceptionally rich ores however have been found in smaller quantities, especially at the Worthington mine in Drury and the Vermilion mine in Denison.

COBALT.

Cobalt amounting to little more than a trace has been detected in many of the Sudbury ores. In connection with the Wallace mine it has been mentioned that in 1848 Dr. Hunt ascertained the presence of cobalt in the ore which Mr. Murray had brought from this locality.

COPPER.

Reference has already been made to the copper always contained in the ores of the Sudbury district. The result of smelting several thousand tons of the ores from the three mines worked by the Canadian Copper Company was a yield of 4.32 per cent. of copper from these ores as placed on the roast heaps. It has been mentioned that the roasting ores smelted at the Blezard mine yielded 2 per cent., and at the Murray mine 0.75 per cent. of copper. In the ores of all the mines the chalcopyrite or copper pyrites is generally so intimately mixed with the pyrrhotite as to make it almost impossible to separate it by any mechanical process. But at the Stobie mine masses of several tons of almost pure copper pyrites are occasionally encountered, and the Copper-cliff mine when first opened showed a large body of the same ore near the surface.

At the Vermilion mine on lot 6 in the fourth concession of Denison copper has been found in paying quantities. The ore consists of chalcopyrite, which however is remarkable for having a deep purplish-blue tarnish, causing it to resemble bornite or purple copper ore. It occurs as a streak about four feet wide in greenstone, but it has no distinct walls like a vein, nor any gangue except a mixture of the country rock. A shaft had been sunk on this deposit to a depth of twenty feet when it was visited by the writer in 1888.

The upper ten feet was decomposed to a loose gossan, mixed with fragments of rock, which had probably been held in the ore streak before its decomposition. The recently discovered mineral sperrylite, which is an arsenide of platinum with a little tin, and which occurs in fine crystalline grains, was found by washing this gossan. Copper pyrites has been found on almost every lot in the fifth concession of Denison, along the southern border of a belt of greenstone that runs nearly east and west through this concession.

A short distance north of the region under description the writer in 1875 met with a group of copper-bearing quartz veins running north 70° west, and south 70° east, crossing the east branch of the Montreal river ten miles and a half before it falls into the main stream. This group of veins is about a quarter of a mile wide. They vary in thickness from mere strings to thirty or forty feet, and contain a good deal of specular iron, and in some places promising indications of copper in the form of pyrites. Mr. Hoffmann found a sample of the specular iron to contain 39.41 per cent. of the metal. The country rock here consists of massive beds of quartzite and greenstone, both holding large bunches or "clouds" of fragments of syenite, quartzite and Huronian schists, and all interstratified with sandstone and clay-slate.

On the north shore of Narrow bay or Baie Fine, and two miles east of its entrance, a small vein cutting the quartzite contains gray copper ore. This bay lies between Frazer and McGregor bays, and the above-mentioned occurrence of copper ore has been described by Mr. James T. B. Ives in the Transactions of the American Institute of Mining Engineers for 1889-90.

The most productive copper mines ever worked in Canada were those of the West Canada Mining Company, which included the Bruce on the east, the Wellington in the centre and the Huron Copper Bay mines on the west. These mines are situated at the western extremity of the north shore of lake Huron, and although they are outside of our present sheet they deserve a brief notice as affording the best examples of the occurrence of copper in the Huronian greenstones. These mines were opened in 1846 and worked till 1875, a period of thirty years. The actual workings extended for a distance of over two miles east and west. The ore occurs principally as the yellow sulphide in veins of white quartz, cutting a dark grayish-green diabase. But when the veins on the Bruce location were first opened a good deal of the purple sulphide was found near the surface. On this location several nearly parallel veins running about east and west were worked, the thicker ones being about four feet wide. But on the other two locations work was carried on chiefly on two master veins called the Main lode, which varied from three to fifteen feet in thickness, and the New or Fire-lode, a branch of the latter, and about equal to it in breadth. On the Bruce location the veins were worked to a depth of only about thirty fathoms, but on the other two locations the average depth was from forty to sixty fathoms. Between the latter levels an almost barren floor was generally encountered, although in some places profitable mining extended to seventy fathoms in depth.

The vein-matter as mined contained an average of five per cent. of copper, but it was concentrated by crushing and jigging to about twenty per cent. before shipping to England, which was the chief market. At different times in the history of these mines both smelting and cementation had been tried upon the ground, and abandoned. From information supplied by Captain Benjamin Plummer and other reliable authorities the writer ascertained that copper ore, precipitates, ingots and slags amounting to 40,515 tons, and realizing about $3,300,000, had been shipped from these mines in the thirty years during which they had been worked.

LEAD AND ZINC.

Small quantities of galena and zincblende have been found in veins in the belt of black volcanic breccia and slate, which has been described as occurring in the Sudbury district, and they are worth mentioning as possible indications that these ores may be discovered in greater abundance in these rocks. One of the localities is on Pawatik river, about a mile and a quarter northward of the Vermilion, in township 65 ; a second is just below Onaping falls, and a third on the south side of Vermilion lake, near the outlet. Vein-like masses of blende mixed with pyrite occur at Stobie falls on lot 10, sixth con cession of Creighton. Galena has been detected with the pyrrhotite in the Copper-cliff mine, and on lot 6, third concession of Graham. It is also associated with this mineral on Moore's location on lots 2 and 3 in the fifth concession of Craig. It occurs in small quartz veins in dioritic schist on lot 5, fourth concession of Denison.

GOLD.

In 1887 a rich auriferous bunch was found in a vein of light gray finely granular quartz about two feet thick on lot 6, fourth concession of Denison. The opening made on this vein came known as shaft No. 2 of the Vermilion mine. The gold was mostly in the form of small nuggets scattered rather plentifully through the quartz. It is said that several thousand dollars worth were mined, but the gold did not appear to hold out in depth. The country rock on this part of the lot resembles a fine grained greenish gray greywacke, but on critical examination it is found to be an altered greenstone full of very small grains of iron pyrites. Prof. George H. Williams, who examined thin slices from two specimens of this rock under the microscope, describes it as an extremely changed basic eruptive, probably originally a gabbro or a diabase—most likely the former. Its present composition is a confused aggregate of chlorite, biotite, epidote, sericite, quartz, pyrite, opaque iron oxide, leucoxene, calcite and apatite needles.

Among the quartzites and greenstones on the south side of lake Wahnapitae a discovery of gold in visible specks was made in 1888. It occurs associated with mispickel in some thin veins of quartz following a belt of quartzite, boulder conglomerate and reddish felspathic quartzite having somewhat the appearance of granite. A sample of the quartz from one of these small veins, which also contained mispickel and pyrite, was assayed by Mr. Hoffmann of the Geological Survey and found to contain 5.425 ounces of gold and 0.233 of an ounce of silver to the ton of 2,000 pounds, but the quartz from another of these small veins contained neither gold nor silver. A band of fine grained dark colored greenstone runs parallel to and at no great distance from either side of this gold-bearing belt of quartzite. It is not unlikely that gold may be found among the rocks of the western part of lake Wahnapitae, which, as already mentioned, have been subject to much crushing in past ages. Gold is reported to have been found by Prof. Heys and others in quartz from veins in the northwestern part of Creighton and the eastern part of Fairbank. Out of a considerable number of samples of quartz from the Sudbury district assayed for the precious metals by Mr. Hoffmann of the Geological Survey, the following results were obtained: From vein No. 1 on mining location W. R. 3, township 40 (southeast of lake Wahnapitae), the property of Mr. Donald McLaren, 0.117 oz. of gold per 2,000 pounds; from location M. 3, at the south extremity of lake Mattagamashing, a short distance east of lake Wahnapitae, owned by Donald McLaren, 1.167 oz. of gold and 0.233 oz. of silver per 2,000 pounds; from Simpson's mine, lot 11, second concession of Graham, near Whitefish station on the Canadian Pacific Railway, 0.350 oz. of gold per 2,000 pounds.

Some distance to the west of our district, or in the western part of the township of Galbraith and about fifteen miles north of Bruce Mines, a large vein of auriferous quartz occurs in a country rock of greenstone. The vein runs about west-northwest, is of a mottled gray color, contains a considerable sprinkling of various sulphides, and is tolerably rich in gold. Of three assays made by Mr. Hoffmann, the highest result was .583 oz of gold per 2,000 pounds.

PLATINUM.

Sperrylite, already referred to as occurring at shaft No. 1 of the Vermilion mine in Denison, was first determined to be a distinct mineral species, containing 52.57 per cent. of platinum, by Prof. H. L. Wells of Yale College early in 1889. Some months previously however Mr. Robert Hedley had ascertained the presence of platinum in the ore of this shaft, the proportion in one assay amounting to about five ounces to the ton It is unlikely that the occurrence of platinum at the Vermilion mine will prove to be the only one in the district; it is more probable that intelligent research will show the existence of this valuable metal in other places among the Huronian rocks. It is reported to have been detected in small quantities at one of the mines on Lake of the Woods.

BUILDING AND ORNAMENTAL STONES.

The red granite of George island and vicinity would make an excellent stone for massive structures and monuments, as well as for ordinary buildings. Many of the evenly and somewhat thinly bedded gneisses of the French river region and of the shore of Georgian bay from French river to Parry Sound would serve as very substantial and tolerably easily wrought building stones.

The nearly horizontal beds of limestone of the Trenton group on the islands in the North channel, at Little Current and on Strawberry island are well adapted for ordinary building purposes and are very conveniently situated for transportation by water. They are mostly fine grained or compact, and of dark bluish and grayish colors.

The dolomites of the Niagara formation further south on the Grand Manitoulin island are more heavily bedded, softer or more porous and much lighter in color.

The light gray and cream-colored dolomites of the Guelph formation are found on the southeastern extremity of Grand Manitoulin island and the south end of Fitzwilliam island, but in these localities they are coarsely spongy or full of small cavities.

On the shores of the high points and islands to the north and west of Killarney the light gray and whitish quartzites in many places would make very serviceable building stones. The bed-planes are generally very even and parallel, and layers can be found of almost any thickness desired.

Some varieties of the greywackes, so common among the Huronian rocks, split readily in any direction, and as they are tolerably easily dressed they may be found suitable for purposes of heavy construction. The argillaceous sandstones of the supposed Cambrian basin of the Sudbury district also afford good building stones and they have been quarried to a small extent on the line of the Canadian Pacific Railway between Larchwood and Chelmsford.

In regard to ornamental stones, the dolomites of the Huronian system when cut often show good colors for marbles, but as already stated they generally contain silica in scattered grains and as strings and threads running in all directions through the mass, which prevents them from taking a good even polish. Exceptions to this general rule may however be found in such cases, for example, as the finely crystalline and nearly white variety found on the north side of Lamorandiere bay in the township of Rutherford, which has not yet been tested as marble.

The olive and greenish argillites barred with black, such as occur at the northern outlet of Temagami lake, and which were so highly prized for ornamental stones by the ancient Indians, may be found serviceable for the manufacture of a variety of artistic objects.

The brecciated green chalcedony, which occurs in abundance at the outlet of White Beaver lake, at the head of the east branch of Montreal river, would form a handsome stone for fine ornamental purposes.

ROOFING SLATE.

It sometimes happens that clay-slates show a good cleavage in natural exposures resulting from the long continued action of surface influences, while the same rock, when freshly quarried deeper down, will not split readily under artificial treatment. It is therefore difficult to pronounce upon the value of such slates without practical experiment. In our district slates showing fair natural cleavage have been observed in various localities, among which may be mentioned the banks of the Matabechawan river which discharges Rabbit lake into lake Temiscaming, Maskinongéwagaming lake and the lower part of Mattagamashing lake, and Spanish river both above and below the Great Bend. It has been already mentioned that a good cleavable slate occurs on the line of the Canadian Pacific Railway within a mile or two east of Algoma Mills. While these slates may not be as good as those of Melbourne and Shipton in the province of Quebec, they are better than the slates used for roofing purposes in many parts of Great Britain, and it is considered worth while to call attention to them among the mineral products of economic value occuring in this region.

LIME.

The limestones and dolomites which make up the bulk of the rocks of the various Silurian formations of the islands of the La Cloche group and of Grand Manitoulin island are well adapted for burning into lime, the calcined dolomite passing under this name. Stone suitable for burning into lime and also for metallurgical purposes may be found among the Huronian magnesian limestones already described at Lamorandiere bay, lake Panache, on Wahnapitae river, near Cartier station and on Geneva lake.

STONE FOR GLASS-MAKING.

Suitable material for glass-making may be found almost anywhere among the Huronian quartzites near lake Huron, where they are nearly all of light colors. In addition to their occurrence in the La Cloche mountains and on the high points and islands towards Killarney, these quartzites are met with on the north side of La Cloche island, at the southern extremity of La Cloche peninsula and in a ridge which runs into Manitoulin island from the head of Sheguiandah bay.

APATITE OR PHOSPHATE OF LIME.

This mineral has not yet been found in economic quantities within our district. It exists however as a constituent of all the greenstones of the region which have been examined under the microscope, and large crystals of it have been met with among the ores of the Copper-cliff and some of the other mines in the district. Numerous crystals of apatite were found in a vein near Nasbonsing station on the Canadian Pacific Railway, east of lake Nipissing. As this mineral may be looked for among the Upper Laurentian rocks generally, it would not be surprising if it should be discovered in commercial quantities in the Nipissing or Parry Sound districts. It occurs in various localities in other parts of the province among the Upper Laurentian crystalline limestones, but elsewhere it is found in larger masses in association with pyroxene rock among gneisses and quartzites, as in the county of Ottawa. Five bands of crystalline limestones among the Upper Laurentian rocks were traced through the Parry Sound district by the writer in 1876, but the region northward of Georgian bay has not yet been sufficiently examined to determine whether pyroxene rocks exist there or not. Should they be met with in sufficient abundance the finding of apatite in economic quantities would be pretty sure to follow.

STRUCTURAL MATERIALS.

There is no lack of materials for building purposes in Ontario, either as regards quantity, quality or variety. And yet it is by no means unlikely that some of the most valuable of these materials remain to be discovered, inasmuch as every year brings something new to light. The great extent of the province, the want of a careful survey of even any part of it, and the lack of interest in ascertaining and developing its mineral wealth are no doubt the chief causes which have combined to keep back a knowledge of the extent and character of the structural materials which we possess; but interest is being slowly aroused, and doubtless our knowledge will keep pace with our opportunities of turning it to practical account. The sandstones, granites, marbles and serpentines which exist in vast bodies on the north shore of lake Superior have not yet been tested in a way to fully prove their value for building material, chiefly because they are too far distant from available markets. But the ease with which shipments may be made to the large cities which border the great lakes give an assurance for the future of quarrying enterprise on the Ontario side of lake Superior when international trade will be put on a better basis than it now is. The same remark applies to the utilization of our material for the manufacture of pressed brick and terra-cotta, for there is probably no portion of the continent in which are to be found such extensive deposits of first-class material as along the northern and eastern limits of the Medina formation, or the outcroppings of the next lowest formation along the north shore of lake Ontario. In so far as building materials of the best quality go Ontario is pre-eminently rich, and it is a safe prediction that within the next half century this fact will be clearly and boldly stamped upon the architecture of the country.

BUILDING STONE.

Building stone is plentiful in Ontario. Granites, sandstones, limestones and marbles are to be obtained in great abundance, although some of them may be at too great distance from the markets to make their quarrying a profitable business yet. The granites and marbles too are so likely to be fractured and flawed by the influence of the weather that it is not easy to procure good samples without opening the beds to considerable depths. Sandstones and limestones are not so susceptible to weather effects, being often found well covered by soil or later formations of rock. This is the case especially in the formations which make up the Niagara escarpment, and convenience of situation to the larger towns and cities of the province encourages the working of quarries there. The Niagara escarpment is indeed rich in building material, for it not only furnishes building stone of the sandstone and limestone classes, but also the materials for lime, cement and brick.

THE QUEENSTON QUARRIES.

The Queenston quarries are located on lot 48 on the Queenston and Grimsby stone road, in the township of Niagara, two miles west of the village of Queenston The lot is the property of William M. Hendershot of Thorold, and the quarries are worked by P. A. Johnston & Co., who have held them under lease since 1881. Previous to that time they had been worked for three years by Hunter, Murray & Cleveland, who had the contract for building the Welland canal aqueduct at the town of Welland; while for the preceding four years, beginning with the spring of 1874, they had been worked by Belden, Denison & Co., who had contracts for the construction of locks on the new canal. It is said that the quarries were first opened during the construction of the Grand Trunk Railway.

Seven quarries have been opened on the property, all of which are in the limeston beds of the Niagara formation.

The several beds differ essentially in color and texture—from light gray to blue, and from soft and porous to dense and crystalline.

After stripping from two to ten feet of clay a gray limestone bed is reached, whos surface has been deeply grooved by glacial action. It is a fossiliferous rock, consisting o lime and sand, and is used in the production of lime and for culvert and bridge works o railways.

Below the gray is a bed of blue limestone of ten to twelve feet in thickness, composed in some of the quarries of two bands, the upper of which is a light and the lower dark grayish blue; in others it is composed of the dark blue only. Both are crystalline but while the upper is coarse grained the lower is fine grained, approaching marble, and is much superior in quality to the other. This bed contains a large variety of fossil shells is hard and durable, tools well, and takes a fair polish. The stone taken from it is used almost wholly for the bases and shafts of monuments, for which a large business has been built up. But it is used also for building purposes, the post offices at Cornwall, Niagara Falls and St. Catharines having been constructed with it, besides many private dwellings and business houses.

Below the blue limestone is a bed of dark limestone, which has a proportion of clay in its composition, is from four to six feet in thickness, and suitable for the manufacture of cement.

Johnston & Co. employ an average of 75 men at their quarries.

BROWN'S QUARRY.

This quarry is in the township of Stamford, on the line between that township and Thorold, and consists of 11½ acres. It was opened about forty years ago by Messrs. Brown & Zimmerman to procure stone for the old canal, and was worked again in 1874 by Belden & Co. during the construction of the new canal.

The land is the property of Mr. James Brown, but the three quarries upon it ar worked under lease by Messrs. Walker Bros., of Merritton; they have been opened to a depth of eighteen feet.

There are two bands of limestone, the upper of yellowish gray and the lower o gray color. Under the gray is a bed of blue limestone, which however cannot be worked for want of drainage. Stone from the upper band is used for curbing, street crossing, flag stones and bridge works, and from the lower for monument bases and window sills.

The firm have a mill at Merritton which runs a gang of ten saws, where stone is cut for window sills, flagging, street curbing, etc. Four quarrymen and three stone-cutters are employed at the quarries.

THE MOUNTAIN QUARRY.

The Mountain quarry is on parts of lots 4 and 5 in the township of Thorold, on the townline between Stamford and Thorold, and consists of 28½ acres. It is owned by Mr. William R. Cartmell, and has been worked by him since 1854, a large quantity of stone having been taken out.

About twelve feet of clay covers the limestone here, which has been stripped from an area of three or four acres.

The quarry has been worked to a depth of twenty-two feet, yielding two qualities of stone. The upper bed, which is nine to ten feet in thickness, is of dark blue color and poor quality, the courses ranging in thickness from two feet at the top to six or eight inches at the bottom of the bed; the stone is used chiefly for backing work.

The lower bed is twelve feet in thickness, and is of light gray color. It is a fine grained stone, and is used for bases of monuments and building purposes.

GIBSON'S QUARRIES.

These are the property of Mr. William Gibson, M.P., and are situated on the top of the mountain a mile and a half south of the village of Beamsville, in the township of Clinton, and two and a half miles from Beamsville station on the Grand Trunk Railway. The property embraces an area of 45 acres, and the limestone rock where not exposed is covered with only a few inches of soil.

The quarries were opened by Mr. Gibson in May, 1884, and have been worked continuously since with a large force of laborers, quarrymen and stone-cutters. The amount paid for wages in 1890 was $87,440, but last year the staff of workmen was increased, and in the month of June 160 were employed ; the wages paid to quarrymen alone in that month being $7,500.

There are two workable beds of gray limestone, the upper being seven and the lower eight feet in thickness. The upper is usually the best quality, being firm, hard and crystalline ; but both contain many fossils, and have openings or vughs which are lined with crystals of iron pyrites. In some parts of the quarries the beds are three in number, but the lowest is not more than two or three feet in thickness. Below these workable beds is a bed of porous gray limestone, but it is rarely of a quality fit for use.

Three large derricks are worked by as many engines, one of which is 24 and the other two of 18 h.p. each, the more powerful one driving a steam drill in addition. Three other derricks are driven by horse-power. A fourth boiler of 35 h.p. drives three steam drills. Three small drills are used for plug and feather work.

The stone is all cut by hand, and is used largely for the construction of bridges, culverts, tunnels and buildings on the lines of the Grand Trunk Railway. The tunnel under the St. Clair river was built by Mr. Gibson with stone taken from these quarries.

The quarries are about 200 feet above the level of the station, down to which the stone is carried in cars over a tram-road built along the side of the public highway. It could be conveyed the whole distance by gravitation, but to prevent accidents the cars are stopped before they reach the main street of the village. From that point they are taken by horses to the station, and empty ones are drawn back to the quarries.

GRIMSBY QUARRIES.

The Grimsby quarries are in the gorge of Forty-mile creek, above the village of Grimsby, which cuts through the limestone into the Medina sandstone and extends back through the mountain to the falls on the creek, a distance of half a mile. The quarries are the property of the Grimsby Quarry Co., of which Stephen Webster of Toronto is president and Frank Webster manager. The location is about half a mile in length, extending from the edge of the escarpment on either side of the gorge to near the falls, and occupying an area of 18 acres.

The bottom and sides of the gorge are covered with a talus of limestone and sandstone, and these stones are being removed preparatory to opening the sandstone in place. A tram-road has been built to the docks at the lake shore, a distance of one mile and a half, down which the cars run by gravitation and up which they are drawn empty by horses, as at the Gibson quarries at Beamsville.

The mountain here is about 350 feet above the lake, and about 100 feet of the top consists of limestone and shale. Underneath the shale are bands of gray, brown and mottled sandstone, alternated with bands of shale. At one place where it is well exposed the brown band, slightly mottled, is about 15 feet in thickness, of good texture, solid and capable of being cut into any suitable size for building purposes.

The company was organised in 1890 with a capital of $20,000, seventy-five per cent. of which was paid up, but although work was commenced in November of that year no stone was taken out until the spring of 1891.

Stone is being supplied for the crib-work at the eastern and western gaps of Toronto harbor, but no dimension stone has yet been taken out. The company employs from thirty to forty men.

Carroll and Vick's Quarries.

Messrs. Carroll & Vick, who took over the contract of the late Lionel York for th new Parliament buildings, are the owners of extensive sandstone quarries at the Forks ‹ the Credit. They began to work No. 1 quarry in June, 1890, and purchased the Adjud Quarry Co.'s property in January, 1891. During the season of last year they worked N 1, 2, 3, 4, 5 and 6, but No. 3 was worked only part time.

All the best stone taken out was shipped for the Parliament buildings, while stone ‹ lower grades was furnished to builders and dealers at Toronto, Hamilton, Guelph, Berli St. Marys and other places.

No. 1 quarry is on the northern side of the west branch of the Credit. It was fir opened by Scott & Pattullo and a lot of fine brown stone was taken out, the limestone ove lying it having been stripped back a short distance. Last year Messrs. Carroll & Vick bega to mine the brownstone at a point where the face showed about twenty-five feet of lim stone above fourteen feet of sandstone. Openings have been made along the face of th sandstone for a length of one hundred feet and back to a depth of eighty-five feet, the ro of limestone being supported by timbers and stone. A beginning is made by taking out tw or more beds of limestone and putting in supports of timber two or three feet in length Then the first bed of brownstone is taken out and the work is carried back and down regu larly. Limestone and poor grades of sandstone are used to fill the place of the stone remove at first by the construction of a regular wall four or five feet thick at the opening, and the by a second wall about fifteen feet farther on, the intervening space being filled up wit rubble. When all the sandstone of a section has been taken out the floor is begun agai at the roof and the timber supports carried forward. The brownstone of this quarry i about six feet in thickness, one bed of which is four feet thick. Below the brown band i four feet of gray, followed by three or four feet of a mixed stone, off color, and extremel hard on its lower side, which consists largely of iron pyrites.

No. 2 quarry is in rear of the railway station on the north side of the Belfountai road. Mining work was commenced there in January of last year in a fine bed of brown stone, which here has a capping of broken shale and limestone about three feet in thickness The work has been carried in a depth of sixty feet and along a face of seventy-fiv feet. There are two gateways to the works, between which supports of stone have bee built back some sixty feet. This quarry yields the best quality of brownstone found a the Forks, the upper bed or course being nine feet and the lower two feet in thickness One section of the upper bed was found to measure twenty-five feet between joints, an apparently free from checks or dries.

No. 3 quarry is on the opposite side of the Belfountain road. It has been worke only part of the year, as a suitable quality of stone was not found there.

No. 4 is the quarry on the east side of the north branch of the Credit. It has no turned out to be as good as appearances at first promised, and all the stone of first qualit has been taken out. A considerable quantity yet remains for coursing, sills and small work as well as for bridge or culvert work or rough masonry. The color is a dirty mixtur and the bedding is very irregular. Below the sandstone is a layer of green shale abou two feet in thickness, followed by a deposit of red shale suitable for the manufacture o pressed brick and terra-cotta whose depth to the foot of the bank is not less than a hundred and twenty feet. It is well situated for this industry, being easily reached fo quarrying and convenient to the railway for shipping. An outcrop of this shale is also seen on the opposite bank of the river, through which the railway has been cut, and is exposed at intervals for more than a mile in length.

No. 5 is on the south side of the main stream, below the Forks, and is known as the York Estate quarry. Four gates have been opened and brownstone has been taken out along a face of two hundred feet back to a distance of sixty feet under the heavy capping of limestone. The brown band is here eight feet deep, and consists of two beds of equal thickness. It is of excellent quality, and one section was measured a length of one hundred feet between the jointings. Mining work was commenced at this quarry in May, 1890.

No. 6 is the property of Dr. Pattullo, and lies east of No. 5, in the same escarpment. It has been leased to Messrs. Carroll & Vick under royalty, and they have been mining stone in it since March, 1891. Two gates are open and one has been abandoned. Work has been carried back a distance of sixty-six feet into a bed of good brownstone seven feet in thickness.

All these quarries except No. 4 are worked as mines, the stone being taken out and the roof supported as described of No. 1.

MYERS' QUARRY.

This quarry is situated on the south bank of the Credit river, on lot 7 in the second concession (west) of Caledon. The property consists of 200 acres, and the quarry was opened by the late M. M. Elliott of Brampton three years ago. In April, 1890, it was purchased by Alexander Myers of Toronto, who has been working it since.

The rock has been stripped along a face forty rods in length, and for a distance of twenty-five rods a large quantity of sandstone has been quarried. It is chiefly gray and gray and brown mixed, making a light shade of brown. The band is about ten feet in thickness, but the color cannot be depended on as it changes in the course of a few feet from brown to gray and piebald. Some of it is being taken out for the Toronto court house and city hall, and it is likely to be used extensively for the inside walls of that building; it is being used also for the Woodstock court house and for various buildings in Toronto.

The machinery at this quarry consists of three engines, three steam drills and a hoisting derrick. The latter is operated by wire cables driven by steam power for lifting and moving, whereby blocks of any size are raised and carried to any desired point for piling or loading. No tag line is necessary, but the engineer with his hand on a lever controls and directs the work swiftly, easily and without interruption, and it is as valuable for stripping as for quarrying. Mr. Myers intends to patent his invention.

The stone is loaded on cars which are taken down a cable road to the railway.

OTHER QUARRIES AT THE FORKS.

Several other sandstone quarries are worked on a smaller scale at or near the Forks of the Credit.

Mr. John Price has leased part of Pattullo's property on the north side of the west branch and has been working it during the past year with a small force.

Armstrong & Dent are also working a small quarry east of Carroll & Vicks' No. 1. They have taken out a little of brownstone, but the bulk is gray and brown.

Another quarry is being opened on the south side of the west branch by William McLaren of Belfountain.

Near Inglewood, below the Forks, Mr. Murray is also opening a quarry of sandstone.

HOOVER & JACKSON'S QUARRY.

This is a limestone quarry situated on the railway line a mile south of Orangeville. It was worked for a short time last year, and a portion of the stone taken out was cut for window sills.

OWEN SOUND STONE CO.'S QUARRIES.

The Owen Sound Stone Company has been carrying on operations for several years at the town of Owen Sound, where it owns a limestone quarry, but recently it has acquired a sandstone property on the Centre road in the township of Mono, two and a half miles north of Orangeville, and began to open it in 1890. It is situated on a flat on the north side of a tributary of the Nottawasaga river, the bed of which is sandstone, eighty feet below the tableland.

After stripping a thin cover of earth and two or three feet of shale, a band of Medina sandstone is reached which is fourteen feet in thickness. It is of a dark bluish color in place, but lightens to gray when dry. The two upper beds of the band are each four-feet in thickness and are of fine quality, being free from dries, easily worked and m be taken out of any required size. The bottom of the third bed is of flinty hardne being made up largely of iron pyrites, so that it cannot be tooled, but the upper part it is of fair quality. The sandstone rests on a bed of greenish shale, which here as els where constitutes the lowest bed of the Medina formation. One block taken out of t top bed measured 5,780 cubic feet and split as straight as if cut by a saw; upon bei cut down for convenience of handling it was found to be perfect, without a dry or flaw

Towards the northern side of the property the first and second beds appear to ru into each other and have there a thickness of eight feet. The dip of the formation northward about 5°.

Shale forms the bed of the stream for a distance of nearly three miles below t quarry, where a hard bluish rock crops out which is supposed to belong to the Huds River formation. The thickness of the Medina shale is estimated to be about a hundr feet, as measured by the fall of the stream.

The company has erected a machine shop on the tableland above the quarry in whi hoisting, sawing and planing machinery have been placed, driven by a 20 h. p. engin The saw and planing machines have been imported from Scotland, and are the same are used in large stone quarries there. They work rapidly and are a very great improv ment on hand labor.

The company intends to build a railway spur to connect with the Canadian Pacif system at or near Orangeville, and when this is completed it will be in a position t carry on operations with much greater economy than at present.

Black Bay Mine and Quarry Co.

The Black Bay Mine and Quarry Company has its principal office in Chicago and it western office at Duluth. It has been organised to acquire and work a location of jaspe and dolomitic limestone in the township of Dorion, near the north shore of Black bay The property was not secured until late in 1891, and only specimen blocks have bee taken out. Both kinds of stone are beautiful in color and take a fine polish, but th specimens seen are more or less flawed, owing no doubt to the influence of the weather o rock so near the surface. The following account of the quarry has been furnished by A M. Stearns of Duluth, manager of the company:

> The company's lands as patented by the Crown are described as the west half of l 8, concession 4 of Dorion, containing 146½ acres.
>
> The property lies about one and one-tenth mile from navigable water in Black ba upon the Canadian Pacific Railway. The outcropping of quarry stone occurs about quarter of a mile west of the railway, on a gradually ascending slope, at about 100 fe altitude, and lying between immense granite hills on the northerly and southerly sides.
>
> It has been noticed and commented upon by explorers as a peculiar formation, but was left to our company to demonstrate that it is a very large and valuable bed of jaspe underlaid with a stone so like mahogany when polished that we offer it to the trade a mahogany stone. The jasper lies at and near the surface, is from three to five feet i thickness, and can be quarried in blocks about three feet wide by five to seven feet long.
>
> The mahogany stone upon which the jasper rests occurs first in thin beds, whic soon thicken to an apparently unstratified ledge and may be quarried in even larger size than the jasper.
>
> Though harder than marble the jasper saws readily and can be satisfactorily reduce with hammer and chisel, taking a polish equal to plate glass.
>
> If one-third of these measurements be allowed for dressing we shall have net dimen sions remaining without flaw suitable for wainscoting, tables, mantels, sideboards, an sizes suitable for turned columns and carved pedestals in fine architectural work.
>
> The whole formation dips slightly to the northwest, and judging from the numbe and uniformly sloping surfaces of the several exposures and the slight stripping betwee them as far as tests have been made it must cover an area of at least forty acres.
>
> The color and the polishing qualities of stone taken from this location will readily commend it to public favor; and should it, as may reasonably be assumed, prove to be free from flaws when a greater depth from the surface is reached it ought to find a ready market.

QUARRIES ELSEWHERE.

Numerous other quarries are worked in different parts of the province, but none others were visited last year excepting one on Pelee island and another in the township of Dunn, near the village of Dunnville, the property of Dr. McCallum. Neither of these were actively worked, although there are at both places large quantities of limestone suitable for building and lime-making purposes.

Hugh Ryan & Co., who are the contractors for the Sault Ste. Marie canal, have taken out large quantities of limestone at White's quarry on the Detroit river, in the township of Anderdon, near Amherstburg, and also from a quarry on Manitoulin island. The stone from the former quarry is got out in large blocks and carried by vessels to the Sault, where it is cut to the sizes required. The Manitoulin stone is not so good for dimension purposes as that from the Anderdon quarry, and is used chiefly as rubble. About seventy men were employed by Messrs. Ryan & Co. at White's quarry last year, and fifty at Manitoulin Island.

In the eastern parts of the province there are numerous limestone quarries, and a few also of Potsdam sandstone, but they are worked on a small scale.

On the north shore of lake Superior there are extensive beds of sandstone, easily accessible by boat, readily worked and of superior quality, in gray, red and other colors; but although some have been opened and worked the business has not proved to be profitable for want of a good market.

PRESSED BRICK AND TERRA-COTTA.

The manufacture of pressed brick and terra-cotta has made good progress in Ontario since the first works were opened near the town of Milton four years ago. There are now seven establishments in operation, and they turned out last year nearly 14,000,000 pieces, valued at $156,700. With form, color and quality in their favor, the products of this industry seem likely to come into extensive use, and they can hardly fail to very much improve the architecture of our towns and cities. The raw material is abundant and easily reached, constituting as it does the lowest beds of the Medina formation, which outcrop along the base of the Niagara escarpment from the Niagara river to Georgian bay, and a large portion of the upper beds of Hudson River shale in the vicinity of Toronto. In Pennsylvania and Ohio the clay used in the manufacture of pressed brick is chiefly drift material, and is neither so firm nor so uniform in its constitutents as our Medina and Hudson River clays.*

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* Volume v. of the Geological Survey of Ohio describes the clay used in the manufacture of pressed brick at Zanesville, which is the principal seat of the industry in the state of Ohio, and also the process of manufacture, as follows:

"The clay, which is probably not far from the level of the Lower Freeport horizon, though there are no coal streaks near by to identify it, is yellow and irony; very like the best clays of the drift, though it is a true bedded formation. In its situation it lies within ten feet of the surface on the tops of several ridges near the town, and it may be an ordinary fire-clay vein weathered to the state in which it is found. It is dug and thrown back in loosely-piled heaps, so that it may further soften and weather. Enough is kept dug to allow it to weather a year before using. It is hauled to the works near by, and is then put into a soaking vat. This consists of a semi-circular depression 3 feet deep, and whose diameter is 30 feet. In the centre of the diameter stands a pug mill delivering away from the vat. This pit is filled with clay by dumping in successive cart loads from the circumference; when full, the vat is flooded from a hose near by until the amount added will make the whole into a stiff mud. It soaks all night in this way in summer; in winter, water is heated in a large cauldron at one side, the flues from which circulate beneath the vat. In this way the clay is warmed first by the water and then kept warm by the fires underneath. The expense of this apparatus for softening clays is light, and it may easily be put up by any mechanic, and it is found efficient in keeping the works going without interruption all winter. The clay is pugged as usual and delivered to the moulder who shapes it. The bricks are covered with a yellow moulding sand or earth which, from the large percentage of iron it contains, assists in giving the bricks the cherry-red color which has done so much to recommend them. The drying is done on an ordinary fire-brick floor. The bricks are pressed in a Miller Brick Press and again dried. They are all rubbed to remove the wire edges, etc., and are ready to set in the kiln. The kilns employed here are very large; at the works visited the two kilns were of 320,000 and 215,000 brick capacity respectively. The walls are permanent and massive; there is no roof but a temporary plank one; the fire-places are large compound ones, each fire-place heating three arches of the kiln. The burning is from ten to twelve days, and the cooling three or four. The setting of the kiln is done very carefully; the common brick are used to make the arches, and are piled up to an even height of about four or five courses above the top of the arch. At the ends and sides they are piled up about one yard thick. In the space left the pressed brick are piled to within one yard of the kiln

BEAMSVILLE WORKS.

William Tallman & Son have been engaged for eighteen years in the manufacture of common brick and drain tile on lots 22 and 23 in the 1st concession of the township of Clinton, near the village of Beamsville. In February, 1890, a sample of the red clay from their land was sent to North Baltimore, Ohio, for experiment, and the product was found to be so excellent that the firm determined to erect works at once.

The clay is the same as is found in the Medina formation all along the escarpment, and is colored a rich brown, with layers or streaks of green near the top. It is disintegrated at the surface, but is found to be solid at a depth of two or three feet, and is so hard at a depth of fifteen or twenty feet as to require a pick for its removal. Three openings have been made from which the clay is taken, but they are down only a few feet.

The works were erected in the spring of 1890 and were opened about the beginning of June in that year. The main building is 30 by 40 feet, the engine room 30 by 24, and the clay shed 60 by 102. The engine is 70 h. p., and the pressing machine is of the Simpson patent, with a capacity 15,000 per day of ten hours. The clay is prepared for the press by grinding and sifting it in a machine which has a capacity of 40,000 per day. The crusher is a revolving disc, nine feet in diameter, in which run two wheels with 18-inch face. Into this the clay is shovelled in a dry state, and being crushed under the wheels it is elevated to a sieve of 16-mesh, through which it falls into a hopper and thence into the press where it is moulded into shape under a pressure of fifty to one hundred tons. From the press the bricks are taken direct to the kilns, which are three in number, and are there burnt to the required hardness.

The works are situated alongside the Grand Trunk Railway, where cars are loaded on a switch to be conveyed to Hamilton, Toronto, Montreal or other market places.

Forty men are employed in the various departments, including wheelers, moulders, setters, burners, sorters and shovellers.

MILTON PRESSED BRICK CO.'S WORKS.

The works of the Milton Pressed Brick Company, of which David Robinson of Milton is president, are on lot 1, concession 1, township of Esquesing, on the line of the Credit Valley Railway, one and a half miles west of Milton. They were erected in 1890, and the first kiln of brick was burnt in October of that year.

The machinery consists of a 90 h.p. boiler, a 75 h.p. engine, crushing and sifting mill, a Boyd press for plain brick, and a hand press for fancy brick. The crusher has two wheels of 14-inch surface and reduces a cartload of clay to powder in from four to ten minutes according to the quantity of water fed upon it. The power press is made for 15,000 per day of ten hours, but in practice it does not exceed 12,600. There are three up-draft kilns in the main building, each having a capacity of 140,000. Wood fuel is used to dry off the brick in the kilns about ten days, after which the burning is finished with soft coal in ten days more.

The clay which supplies the raw material lies on the slope between the works and the mountain, and a pit has been opened into it to a depth of twenty-five feet. After stripping off the surface soil of yellowish clay, which is about a foot in depth, a bed of

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top; above, the common brick are again piled, so that the pressed brick are in shape of a rectangular solid, separated by at least a yard of common brick from the walls on all sides or the air above and the fire below. By this means the utmost uniformity of burning is secured, and of the production at least nine shades of color are separated. The brick are each one subjected to a critical examination, and are rejected for a defect invisible to one unpractised in the examination. Many ornamental shapes are made to relieve the monotony of a plain wall; some of them are truly artistic, such as tiles, one foot square, containing well-drawn designs, etc. The price of the plain pressed article of any shade is $20 a thousand, or two cents apiece, and ornamental shapes are just twice as much. These Zanesville brick are well known in the markets, and they meet but little competition in Ohio, though Cleveland and Liverpool both make pressed brick. The sharpest competition and the best market is in Chicago." (pp. 704-5).

A more detailed account of the process of making pressed or repressed brick is given in Morrison's Brickmakers' Manual (Indianapolis, 1890) pp. 67-77, but it does not appear to be an improvement upon the one described above. For plain and ornamental brick the clay is mixed with water, moulded, dried in part, then well sanded and pressed again, after which it is burnt in the kiln.

reddish-brown clay with streaks of green is exposed twelve feet in thickness. The green clay burns white when used alone, and when mixed with the red the brick is light and irregular in color; therefore it is picked out by the quarrymen to be worked by itself, or to be mixed with the dark clay so as to produce brick of uniform color. Under the twelve-foot bed is one three feet in thickness of red and green clay, the latter partially decomposed so that the clay has a worm-eaten appearance. It is almost as hard as stone, and as it burns light in the kiln it is not now used. The third bed is of a uniform reddish-brown color, lighter than the upper one, but very compact and of unknown depth. It is apparently the shale of the Medina formation in place, while the upper beds are a redeposit. The clay of the first layer is found to shrink more in burning than the third, although the color is more pleasing; but the best quality is obtained from a mixture of the two clays.

Twenty men are employed at the works, including quarrymen and shippers. The brick is carefully selected, packed into cars on the siding, and shipped mostly to Toronto

TORONTO PRESSED BRICK AND TERRA-COTTA CO.'S WORKS.

The Toronto Pressed Brick and Terra-cotta Company was organized in 1888 with Hewson Murray, Q.C., of Toronto at the head of it, and is the pioneer of the pressed brick industry in Ontario. Its works are on the line of the Credit Valley Railway, on the mountain slope about two miles west of Milton. The quarry lies between the works and the mountain, and the beds of clay resemble very closely those of the Milton company's quarry. The uppermost bed, which is covered with a foot and a half of soil and yellow clay, is a loose friable clay about four feet in thickness; it is of fine brown color, but contracts in the burning. A foot of green with two or three feet of streaked and light colored clay makes up the second bed, which is more compact and less friable than the one above it. The third bed is worked to a depth of five feet and has the consistency of rock. It is found in practice that the best quality of brick, uniting color and strength, is obtained by mixing clays of the first and third beds.

The company has an extensive plant, consisting of an engine and boiler of 105 h.p., grinding and refining machinery, three power presses, five hand presses for fancy brick and tile, pug mills to prepare clay for terra-cotta work, and seven kilns with a total capacity of 750,000.

The fuel used in the kilns is bituminous coal, and the average time of burning is about two weeks. The average capacity of the presses is 30,000 per day of ten hours.

The product of the work is chiefly pressed brick, red, brown, buff and white in colors; but a specialty is also made of moulded and ornamental bricks, terra-cotta in pattern for walls and interior decorations, and tile for roofing, including in the latter finials, hips, valleys and angles.

The market for the output of the works is found largely in Toronto, where a number of handsome dwellings and office buildings have been erected with material which this company has supplied, including among others the Confederation Life building on Yonge street, one of the largest and most imposing structures in the city. But sales have been made in all parts of the Dominion, from Charlottetown in Prince Edward Island to Victoria in British Columbia.

The works employ an average of sixty men for ten months of the year, but are closed during the very cold weather for necessary repairs.

ONTARIO TERRA-COTTA AND PRESSED BRICK CO'S WORKS.

The Ontario Terra-cotta and Pressed Brick Company was organised in 1889, with Mr. M. L. Livingstone of Toronto as president, and in the same year operations were commenced at Campbellville station on the line of the Credit Valley Railway.

The buildings are of brick material and are well equipped throughout. The plant consists of an engine of 75 h.p., grinding and screening machinery, a pug mill to mix clay for terra-cotta work, two steam presses for plain and moulded brick, three hand presses for roofing and flooring tiles and ornamental brick, six round kilns, a large square kiln and a trial kiln.

The larger of the power presses is used only in moulding plain brick and has a working capacity of 13,000 per day; the smaller, used in making moulded brick, has a daily capacity of 2,500. The round kilns take in 30,000 each at a burning, and the large square one 65,000, the fuel used in them being wood and soft coal, the latter in the finishing stage. A new and more powerful engine is being placed in the works this year, and the plant in other respects will be enlarged and improved. Architectural terra-cotta in many large and handsome designs is a special feature of these works. Except in the preparation of the clay, terra-cotta is a product of the sculptor's hand, unless a number of pieces of the same pattern are required, when a cast in plaster of Paris is made. Four skilled designers are employed in this branch of the work.

The company's quarry is at the falls of Limestone creek in the township of Nelson, on the Guelph road, about three miles south of the works. The gray band of the Medina sandstone crops out here at the surface and has a thickness of ten feet. Underlying it is a bed of green shale three feet in thickness, and below the green is the red shale of the Medina formation which has an exposure in the gorge of the creek below the falls of a hundred feet in thickness.

It is a very solid deposit and shows jointings at intervals, the edges of which have been stained about six inches on either side by the decomposed green shale which has percolated from the bed above. Lateral streaks of green shale are also seen in places, but the body of the deposit is very uniform in color. It has the compactness and firmness of stone when first taken out, but soon yields to the disintegrating influences of the weather.

The shale has been worked to a depth of thirty feet along a face of two hundred feet, and without doubt there is an immense body of it on the company's location, which extends along both sides of the gorge below the falls.

The brick made from this clay has a distinct metallic ring, and the percentage of loss from fracture or the chipping of edges in the kiln is comparatively very small, fully 75 per cent. of the whole turning out firsts in the grading. The shale contains so large a proportion of the oxide of iron as to be suitable for the manufacture of mineral paint, and this industry was carried on here for many years.

The clay is teamed by farmers of the locality to the works at Campbellville during the winter and when farm work is not pressing in other seasons of the year, for which they are paid a certain rate per ton.

The number of men employed at the works and the quarry, exclusive of teamsters, ranges from 25 to 30 for the whole year.

The best market for the product is in Montreal, where it has been used in the construction of several large buildings, but it has also been in good demand in Toronto and other cities and towns of Ontario.

DON VALLEY PRESSED BRICK WORKS.

The Don Valley pressed brick works are the property of Taylor Brothers of Toronto, and are located at the mouth of the third ravine on the west bank of the river, between the Belt Line Railway and the Don spur of the Canadian Pacific.

Experiments made with the clays of the locality resulted in showing that pressed brick of superior quality could be produced from the shale of the Hudson River formation which outcrops at the base of the bank at several points along the river, and early in 1891 Taylor Brothers started to erect works and fit them with plant of the best and most modern description. This consists of two power presses having a capacity of moulding 30,000 brick daily, one with a capacity of 10,000 and a fourth of 4,000, or a total of 44,000 per day, together with grinding and screening machinery in which the clay is prepared for the presses. These machines are driven by an engine of 175 h.p.

Several buildings have been erected on the premises for burning the brick, eight kilns in which have an aggregate capacity of 1,100,000. The period of burning depends on the size of the kiln and ranges from four or five days to three weeks.

The Hudson River shale, where a quarry has been opened about fifty yards from the works, rises ten feet above the level of the valley. A bed of till three feet in thickness overlies it; this is a tough, indurated clay, the general character of which has been well described by James Geikie in his work on the Great Ice Age.* Over the till is a bed of sand twenty-five feet in thickness, interbedded with thin layers of clay, and over the sand a deep bed of stratified Saugeen clay which rises nearly to the top of the bank, 140 feet above the valley of the river. This clay contains a proportion of lime, is light in color, fine in texture, and burns a beautiful buff. When mixed with the clay of the Hudson River shale, which burns a deep red, a variety of pleasing colors is produced, from which handsome effects in the architecture of outside and inside walls, fireplaces, etc., may be obtained.

The Hudson River shale has been quarried to a depth of twenty-five feet. Thin seams of limestone occur in the shale, which have to be culled out before the material is sent to the grinding mill. The soft shale which makes up much the greater part of the formation as seen in the quarry decomposes readily and is easily worked in the mill, but some beds of it are much harder than others and disintegrate slowly. It burns to a deep red color, the brick is strong and heavy, and has a clear, sharp, metallic ring.

The dip of the Hudson River formation is southward, and the shale disappears below the level of the valley near the crossing of the Belt Line Railway. The jointings have an east and west course, and their presence greatly facilitates the work of quarrying.

The number of men employed in the works and at the quarries is fifty-five, exclusive of teamsters.

Markets for the product of the Don Valley works have hardly been established yet, but there is a fair prospect of shipments being made to Buffalo and other American cities.

OTHER WORKS.

Works for the manufacture of pressed brick and terra cotta upon a small scale have been erected in the counties of Frontenac, Huron and Peel, and a new company has been organized which is erecting large works in the Don valley between the second and third ravines of Rosedale.

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* "The deposit known as till is usually a firm, tough, tenacious, stony clay. So tough indeed does it often become that engineers would much rather excavate the most obdurate rocks. Hard rocks are more or less easily assailable by gunpowder, and the numerous joints and fissures by which they are traversed enable the navvies to wedge them out often in considerable lumps. But till has neither crack nor joint—it will not blast, and to pick it to pieces is a very slow and laborious process. Sometimes the stones in the till are so numerous that hardly any matrix of clay is visible. This, however, does not often happen. On the other hand they occasionally appear more sparsely scattered through the clay, which may then be dug for brick-making; but this occurs still less frequently. As a rule it is hard to say whether the stones or the clay form the larger percentage of the deposit in a mass of typical till. . . There is something very peculiar about the shape of the stones. They are neither round and oval like the pebbles in river gravel or the shingle of the sea shore, nor are they sharply angular like newly fallen debris at the base of a cliff, although they more closely resemble the latter than the former. They are indeed angular in shape, but the sharp corners and edges have invariably been smoothed away. Each is smoothed, polished and covered with striæ or scratches, some of which are delicate as the lines traced by an etching needle, others deep and harsh as the scores made by the plow upon a rock. But what is also worthy of note, most of the scratches, coarse and fine together, seem to run parallel to the longer diameter of the stones, which however are scratched in many other directions as well. . . Each stone in the till gives evidence of having been subjected to a grinding process. Almost every fragment has been jammed into the bottom of a glacier, and, held firmly in that position, has been grated along the rocky surface underneath, or over a pavement of the tough stony clay itself. In such a position the stones would naturally arrange themselves in the line of least resistance; hence it is that the most distinct ruts and striæ coincide with the longer diameter of the stones." pp. 10, 11, 14, 76.

The cutting of the Canadian Pacific Railway in the township of York, a short distance east of the north bank of the Don, is an illustration of the difficulty of excavation here referred to. The contractor for that section once told me that it was the hardest piece of work he had ever experienced in railway construction; it could neither be picked nor blasted. The bed of till in this cutting however is considerably thicker than in the exposure at the brick works. The stones are for the most part of Hudson River formation where examined, but they belong also to older formations, including granites and gneisses and all are glaciated. The new sewer on Wellington street cuts into this bed of till at a depth of fifteen feet below the street level, out of which fine specimens of striated stones and small boulders have been picked.

NATURAL AND PORTLAND CEMENTS.

Hydraulic cement is of two kinds, known generally as the Natural and the Portland cements. The former is the product of an impure limestone found in certain parts of the Trenton and Niagara formations, and composed of lime, magnesia and clay in more or less definite proportions, found in the native state. The latter is an artificial product, obtained by mixing and treating carbonate of lime and clay in certain proportions. In his valuable pamphlet on Hydraulic Cements, Mr. Uriah Cummings of Buffalo thus describes the Portland cement:

> In the manufacture of Portland cement in England the clay is mostly selected from the river beds and the carbonate of lime from the chalk deposits which form a large portion of England's surface, and is a nearly pure carbonate of lime.
>
> Limestone is used wherever the chalk is unobtainable in some parts of England and Germany and elsewhere, and is finely pulverized preparatory to its mixture with clay.
>
> These two ingredients are usually mixed together in a pug mill, with a free use of water.
>
> Sometimes however they are ground together in a comparatively dry state.
>
> But in either method the quality of the cement depends greatly on the thorough admixture of the two materials, it being more important even than a proper combining proportion, although the latter is essential to the production of a first-class cement.
>
> After these materials are incorporated into a homogeneous mass it is dried and made into blocks or bricks and placed in suitable kilns for calcination.
>
> The material as it enters the kiln, whether it be an artificial mixture or a natural cement stone, is a mechanical combination of two chemical compounds, *i. e.*, silicate of alumina and carbonate of lime.
>
> The preliminary operation in calcination is the expulsion of moisture, which is soon followed by the carbonic acid contained in the carbonate of lime.
>
> Then a chemical reaction takes place. Under a high temperature in the kiln the lime rendered caustic by the expulsion of the carbonic acid, and in intimate contact with the silicate of alumina, the latter is decomposed and a new combination is formed, known as silicate of lime and alumina.
>
> If magnesia be present, then a triple silicate of lime, magnesia and alumina is formed.
>
> In a Portland cement, however correct may be its proportion of ingredients, the clay and carbonate of lime must be thoroughly and intimately mixed.
>
> Each atom of silicate of alumina must come into close contact with its equivalent of lime carbonate.
>
> A failure in this regard will result in the production of a cement that will heat, check and expand, thus showing the presence of free or caustic lime, or free clay, and no amount of subsequent grinding or mixing will change these conditions, thus showing conclusively that the silicates can only be formed during calcination, with the silicic acid and the bases in the closest possible contact.
>
> The Portland cement manufacturer has it in his power to control the proportions of the materials he uses, and renders it possible for him to make his product uniform.
>
> Careful attention to proportions and mixing and care in the matter of calcination will produce a cement that seemingly leaves little to be desired.
>
> But so long as these details are entrusted to the hands of ordinary laborers—and there seems to be no other way—so long as the natural cements sustain their present reputations, and through their very cheapness keeping down the price of Portland, none but the cheapest class of labor can be employed in the manufacture of artificial cements, and no matter how vigilant the superintendent may be there will be failures, and sometimes disastrous ones.*

The same authority in referring to natural cement says:

> In all natural cement rock formations we find the deposit to consist of several layers or strata, and these layers rarely contain the same proportionate amount of ingredients.
>
> As a rule the lower layers contain more clay than those above, the proportion of clay gradually diminishing and that of carbonate of lime increasing as we ascend in the series of layers.
>
> There are exceptions to this rule, but with these included there are no cement rock deposits in this country that are known and operated that do not show a variation in the proportions of clay and lime carbonate among the several layers, amounting in some deposits to as high as 20 per cent. And so it may be seen that although the cement produced from such deposits may after a thorough mixing—first in the kiln and then in the grinding—exhibit by analysis a cement made up of very fair proportions, it also shows that it is not impossible to find that a cement may be heavily over-clayed, and still contain free or caustic lime. And it must be seen that although the proportions may be correct, yet

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*Hydraulic Cements, Natural and Artificial; their Comparative Values, by N. Cummings, pp. 3-5.

> the amount or percentage of the true silicates cannot be predicated on such analysis, for the reason that two distinct layers of diverse proportional ingredients, when placed together in a kiln, cannot form a chemical combination. The excess of lime in one fragment of a rock cannot combine with the excess clay in another, and it is only a mechanical mixture when ground together in the mill.
>
> Variations are sometimes found in a single layer of the same quarry, and it is a rare thing to find uniform quality in quarries of the same neighborhood.
>
> Fortunately excessive variations are rarely to be met with, but it is to these facts alone that may be attributed about all the superiority that can reasonably be claimed for an artificial cement over the natural production.*

Again as to the enduring qualities of cements Mr. Cummings says in the same pamphlet:

> The setting of a cement becomes slower as the proportion of lime is increased, until we pass up through the slow-setting hydraulic limes and arrive at the pure limes where crystallization ceases.
>
> All doubts in regard to the superiority of the over-limed cements must disappear when we study the wonderful record made by hydraulic limes, a material containing so much free lime as to prevent its induration when subjected to immediate immersion, and usually so after several days in the air. Although the free lime may have been thoroughly hydrated, they therefore pass beyond the limits of what may be termed hydraulic cements. Yet if given four to eight weeks in the air in masonry or concrete they will bear immersion as well as the best hydraulic cements, and it is yet to be proven that they are not superior in that respect, and for exposed masonry they are immeasurably so.
>
> If we care to build for all time, we must remember that that which causes a cement to set promptly under water is also the cause of its comparatively early disintegration when exposed to the atmosphere.
>
> A cement therefore that carries so much lime as to require three to six months to harden in exposed masonry will be found in perfect condition ages after the mortar made from quick-setting cements has crumbled out and disappeared.
>
> When the famous civil engineer John Smeaton of England built the Eddystone lighthouse, commencing in 1757, he used the Aberthaw hydraulic lime, the analysis of which was as follows: lime 81.16, clay 18.84=100.
>
> According to the analysis the lime contained 62 per cent. silicate of lime and 38 per cent. free or caustic lime, and of course was slow-setting, so slow in fact that Smeaton resorted to the use of plaster of Paris to cover the joints in the masonry to protect them from the sea, and he found it to remain long enough for the lime mortar to harden.
>
> This lighthouse stood in perfect condition over 100 years, and until taken down to make way for a larger one.
>
> Here we have an illustration of the durability of a natural cement containing so much free lime that it could not bear immediate immersion, and it is doubtful if it would stay up under water after a week's exposure to the air. To be sure he used Italian pozzulana with his hydraulic lime instead of sand, but there is nothing hydraulic about that. It is simply burnt clay containing occasionally a small proportion of lime. . .
>
> The hydraulic lime of Teil in France, the composition of which is substantially the same as the Aberthaw lime, has been in use in the form of concrete made into blocks for sea walls for the past 55 years, without showing any signs of disintegration. The manufacture of Teil lime exceeds two million barrels annually.
>
> Neither of these hydraulic limes can be made to test 10 pounds in 24 hours, if given but an hour in air, and they would stand a poor show in this country where quality is gauged by the testing machine.†

Mr. Cummings is not a wholly disinterested man, having himself been for many years employed in the manufacture of natural rock cement; but probably the favor with which artificial cement continues to be received to the present day is due in some measure to prejudice. Makers of the natural rock cement in Ontario complain that it is impossible to obtain a fair test where works of an important character are being carried on, and since streets have commenced to be laid with asphalt pavement in our larger towns and cities the demand for cement has largely increased. Yet artificial or Portland cement has the call over natural cement at less than half the price.‡ There may however be some compensation in this now that the production of artificial cement has been commenced in Ontario.

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*Cummings' Hydraulic Cements, pp. 7-8. †Ib. pp. 20-22.

‡In two years 1890 and 1891 there were used on corporation works in the city of Toronto 28,000 barrels of Portland and only 200 barrels of natural rock cement, the former costing about $2.70 and the latter about $1.15 per barrel. In 1890 10,000 barrels of natural rock cement from the Thorold works was used in the construction of the St. Clair tunnel.

QUEENSTON CEMENT WORKS.

These works are on the Hendershot lot in the township of Niagara, on the Queenston and Grimsby stone road. The quarry was formerly worked for building stone, but a bed of cement rock underlying the blue limestone having been exposed by the removal of the latter it was found that a new industry could be profitably established. The cement bed varies in thickness from two feet on the west to six feet on the east side of the quarry, but the proportion of lime is too great in the upper part of it so that care has to be taken to cull it out.

Messrs. Usher & Son of Thorold are lessees of the quarry, but the works are carried on by Mr. Edwin Tyler, who manufactures for them at a fixed price per barrel. The plant is maintained by Usher & Son and consists of two burning kilns and a mill of two run of stones to grind the rock. After being ground it is run through a cylindrical screen of rolled steel of 55-mesh for which Mr. Tyler has obtained a patent. This screen has a capacity of 150 barrels per day, but is run at 100 barrels. The kilns and grinding mill have a capacity of 600 barrels per day.

Mr. Tyler has had an experience of twenty years at the Akron cement works in the state of New York, and from his knowledge of the trade there he does not doubt but cement could be produced in Ontario at a cost to compete in the markets of that state even in the face of the present duty. The works employ six men, four of whom are quarrymen, and with the service of a steam drill 500 barrels of rock can be taken out per day.

THE THOROLD HYDRAULIC CEMENT MILLS.

The business of the Thorold Hydraulic Cement Mills is carried on under the title of Estate of John Battle. The quarries are in the town of Thorold, on the east bank of the new canal, and were opened by the late John Brown in 1841, the location having an area of 44 acres. The cement bed is overlaid with ten feet of crystalline limestone, capped with ten feet of clay. In the summer season the stone is quarried in an open cut, but in the winter and in broken weather the men work under rock cover, the bed having been tunnelled and mined out to the extent of an acre. The limestone roof is supported by pillars which have been left standing at intervals, or which have been built up after the removal of the rock. The bed of cement stone is from ten to twelve feet in thickness, and is generally of uniform quality; but in the upper layer and sometimes in the body of the bed the proportion of limestone is too high for the production of a strong cement. From the quarry the stone is carted to a bank of five kilns, where it is built up with layers of soft coal and fired. The process of burning is accompanied with loud detonations, caused by the conversion of the moisture in the stone into steam, and fragments are occasionally thrown out of the kilns with considerable force; one of the attendants last year lost an eye from a blow received in this way. Five or six days are required to burn a kiln; or rather this time elapses before the work of drawing off begins after the kilns have been fired. Cinder or slag is formed in the burning, and care must be taken to cull out such pieces as their presence would prove injurious to the cement. The calcined stone is taken from the kilns to the mill, which is situated on the old canal and is driven by water-power which the canal supplies. It is first run through a breaker, and thence by elevators it is carried to three-run of buhr stones and ground to the requisite fineness. The grinding capacity of the mill is twenty-four tons per day, or 200 barrels of 240 lb. The yearly output is 30,000 barrels, the usual selling price of which is $1 per barrel.

The cement is submitted to a daily test; bricks of it are made which are left in the air to dry for one hour, put into water for twenty-three hours and then tested for breaking strain with an Acme machine. A breaking strength of from 75 to 100 lb. is regarded as satisfactory, but it runs up to 200 and over. Should the test fail it is assumed that the rock of the quarry contains a too high per centage of lime and the part from which it is taken is abandoned.

LIMEHOUSE WORKS.

The Limehouse cement works are the property of the Toronto Lime Company, and are situated on the main line of the Grand Trunk Railway where that road makes the ascent of the Niagara escarpment. The occurrence of the cement rock is the same as at Thorold, being at the base of the Niagara limestone. The works have been carried on for many years, but the industry is not so important as lime-making and the output of last year was not very large.

RATHBUN & CO.'S CEMENT WORKS.

The cement works of Rathbun & Co. are located at Napanee Mills, in the county of Lennox. The manufacture of natural rock cement has been carried on there for ten years, the material being found in the Trenton limestone of the locality. For the last three years this cement has been used on Government works; it has been carefully tested and is found to give good satisfaction.

For the past five years the company has been experimenting with Portland cement, using for that purpose the shell marl found in several deposits along the line of the Bay of Quinte Railway. The principal deposit is near Marlbank station in the township of Hungerford, and covers an area of eight or ten square miles, occupying the basins of White lake and Dry lake. Pole tests have shown it to be in places twenty feet deep. Clay to mix with the marl is found on the company's land at Napanee Mills, and it is claimed that the composition in certain proportions makes a cement of the best quality. As shown by analyses the average consists of

Carbonate of lime	64.04
Magnesia	1.98
Silica	21.57
Lime and alumina	12.21
Carbon dioxide	0.25
	100.05

A record of the tensile strength per square inch of Portland cement produced at these works shows at three days 303 lb., at four days 425 lb., at six days 460 lb., and at seven days 500 lb. This is for cement containing 22 per cent. moisture. With cement containing 28 per cent. moisture the breaking strain at eleven days was 510 lb. A sample broken at 400 days yielded at a strain of 833 lb., and one at 420 days at 865 lb.

Three kilns have been erected for Portland and three for natural rock cement. and the grinding capacity of the mills is 500 barrels per day.

ENGLISH PORTLAND CEMENT CO.'S WORKS.

A company organized under the title of the English Portland Cement Co. commenced last year the erection of works at Marlbank, in the county of Hastings, and expects to begin operations some time this year. The material is found in great abundance in the locality.

NORTH AMERICAN CHEMICAL CO.'S WORKS.

The North American Chemical, Mining and Manufacturing Co. was organized at Owen Sound in 1889 for the manufacture of Portland cement. Its capital is $100,000, of which it is stated that $60,000 has been paid up.

The works are situated on the shore of a lake, known as Shallow lake, in Keppel township in the county of Grey, occupying lots 6, 7, 8 and part of 9 in the 7th concession. The area of the location is 596 acres, including several small islands, and about 500 acres is under water for half the year.

Two streams flow into the lake, and in the dry season they unite near the works on the northern side, the channel continuing about 300 yards in a farther northwesterly direction towards the margin of the lake, where the waters disappear with a loud rumbling noise through a series of sinkholes in the limestone bottom. Evidence of the suction power here is seen in the mass of timber and debris which has been drawn around the sinkholes, as well as in the arrangement of the limestone boulders themselves, which take the shape of an inverted cone. Doubtless this is the source of many of the springs in that section of country, as the Niagara limestone is much fissured. The height above the level of Georgian Bay is here about a hundred feet.

The streams continue to flow the year round, but are highest in the months of April and May when the lake has an average depth of five feet. In June or the latter part of May the water begins to fall, and about the first of July the lake becomes dry over its whole bed, showing white masses of marl at many points of its surface; in December it begins to fill again.

The bed of the lake is covered with shell marl to depths ranging from one to six feet, the average being about four feet. Underlying the marl is a bed of clay two feet in depth, which by experiment has proven to make a strong Portland cement when mixed with the marl in definite proportions. Below this clay are alternate layers of sand and clay of a tough, spongy nature, and in places where excavations have been made the ground quakes like a bog. The marl and clay used in the manufacture of cement are taken out during the dry season and carted to the works.

The main building of the works is constructed of rubble stone, 270 feet by 40 feet, and was erected in 1889.

The wet process was first adopted in the manufacture of cement, the mixture being burnt in a Ransome cylinder, but it did not prove satisfactory. Operations were also delayed for some time on account of litigation between the company and the owner of the location, and when matters were finally settled it was decided to remodel the works according to the English system. For this purpose the manager of the company, Mr. Butchart, visited England last year and spent some time in examining a number of the best works there. He secured the service of three experienced men to have direction of the works, and after his return the improvements were commenced and carried on to completion by the end of the year.

Kilns have been substituted for the cylinder, a new mixing machine has been constructed and an engine of 250 h.p. has been put in to drive all the machinery of the works except that used in the manufacture of heading and staves for barrels.

The capacity of the works as completed last year is 75 barrels per day, but it is proposed to increase it during the present year. In the month of September forty men were employed by the company, constructing the works and taking out material.

GYPSUM.

Although gypsum is used largely as a fertilizer in districts within easy reach of the mines—the charge for freight circumscribing it for this purpose to comparatively narrow limits—its employment as a building material is now gradually extending, so that it may be properly classified under this head. Large quantities of gypsum are reported by explorers and officers of the Geological Survey to form the upper beds of the Devonian system on the Moose river and its tributaries, but these are too far distant for any available means of communication, even were the demand much larger than it now is or is likely to be for many years to come. The only workable deposits in the province within reach of markets occur in the Onondaga formation along the Grand river, and their occurrence is described as follows by Logan:

> The outcrop of this gypsiferous formation extends from the Niagara river to the Saugeen on lake Huron, a distance of about one hundred and fifty miles; but the gypsum mines at present known are all found within about thirty-five miles, on the Grand river, extending from Cayuga to Paris. It is probable however that as the country to the northwest of Paris becomes more settled farther discoveries of gypsum beds will be made in that direction. To the southeast of Cayuga the overlying Drift conceals any beds of gypsum which may be present. All of these deposits seem to be confined to one stratigraphical position, which is probably about the middle of the formation. The gypsum occurs in beds which thin out in such a manner that they present the form of lenticular masses. These vary in horizontal diameter from a few yards to a quarter of a mile, and are from three to seven feet in thickness. The strata above them are arched and broken, while those beneath present an undisturbed level floor,

the two coming into contact at the edge of the masses. This peculiar structure gives rise to mounds on the surface, which are regarded by the inhabitants of the region as indications of the presence of beds of gypsum below.*

GRAND RIVER PLASTER CO'S MINES AND WORKS.

The mines and works of the Grand River Plaster Company are on lots 2 and 3 in Huff's tract in the township of North Cayuga, four miles southeast of Cayuga village, near the junction of Naughton creek with the Grand river. Two mines have been worked on this property, but one was shut down twenty-five years ago.

The mine on the more northerly lot opens near the bank of the creek and an adit has been driven a distance of about three hundred yards to a shaft sunk through the Drift and overlying limestone to the bed of gypsum, a depth of thirty feet. Four side drifts have also been extended to lengths ranging from fifty to a hundred yards, and from these the gypsum is now being mined.

A tramroad is laid down on the main adit and its branches, along which the rock is drawn out by a mule, and as the height of the roof is only four and a half feet, mule and workmen are bound to carry their heads low. The track is level, or nearly so, from the shaft to the mouth of the adit, and about a ton of rock is taken out with each carload.

The quality of the rock is variable, being in places nearly clean white gypsum and in others the gypsum occurs as nodules of different sizes in the limestone.

In former years twenty men were employed at the mines and works and thirteen cottages have been erected on the property for the accommodation of workmen, but during the past year only two miners were employed. A mill for grinding plaster of Paris was erected about twelve years ago, and works for the manufacture of calcined plaster four years ago.

TEASDALE'S MINE.

On lots 1 of the Huff tract and 4 of the Jones tract, in the township of Cayuga, Mr. Thomas Teasdale began opening a mine two years ago and has driven in an adit a length of eighty yards. The work however is much hindered since the raising of the dam on the Grand river at Dunnville, the waters at some seasons of the year rising to the level of the mine and flooding it.

The depth of the gypsum bed is four feet, and the upper portion of it is of fine quality, being a pure white color and free from limestone. The drift clay generally rests upon the gypsum where openings have been made, but in places a thin bed of shale intervenes.

Two shafts have been sunk on this property about thirty rods from the mouth of the mine, one twenty-five and the other seven years ago, and the bed of gypsum was struck at a depth of forty feet.

Mr. Teasdale says his father, who was a practical miner, came from England in 1842 or 1843 to open the mines on the Grand River Company's property. The product of this quarry is sold to the Alabastine Company of Paris.

ADAMANT MANUFACTURING CO'S MINE.

The Adamant Manufacturing Company has its headquarters at Syracuse in the state of New York, but it has branch establishments in Toronto and in several cities of the United States. Its mine is located on lot 2 of the Jones tract on the River road in North Cayuga, and has an area of 65 acres. It was opened in 1875 by the late A. W. Thomson and four years afterwards was acquired by Gill, Allan & Brown of Paris, who in September, 1890, disposed of it to the present company.

A working shaft through clay with a descent of one foot in ten reaches the limestone cap rock at a perpendicular depth of 45 feet from the surface. This bed is five feet in thickness, and is of sufficient strength to support the weight of overlying clay where th opening does not exceed six feet in width.

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* Geology of Canada, p. 762.

The gypsum bed ranges from three to six feet in thickness, the average being abou four feet, and it rests on limestone of extreme hardness.

The working shaft has been driven through the gypsum a total length of tw hundred yards from its mouth, and near the extreme end it intersects a ventilating an draining shaft at a depth of fifty feet from the surface.

Five side drifts have been opened, one of ten, one of twenty, one of twenty-five, on of fifty and one of a hundred yards, which have been worked laterally in places to widt of 25 or 30 feet. The capping is at first supported by timber and afterwards with rubbl stone from the mine securely built in.

The bed of gypsum runs parallel with the surface, and the foreman claims to hav no difficulty in determining the boundaries of the field from the contour of the surfac

The bottom of the mine is near the level of the Grand river, four hundred yar away, and when the water in the river rises the mine is threatened with inundatio Last spring, during floodtime, the water poured in between the cap rock and the gypsu bed, and the two pumps were tested to their fullest capacity to keep it under contro The pumps are driven by wind power.

The upper portion of the bed is a nearly pure white gypsum, but the lower contai a large percentage of limestone and is not suitable for the best classes of work unle carefully selected.

A mill to grind plaster was built on the location soon after the mine was opene and was run until 1879, when the output of the mine intended for plaster was shipped t Paris and ground there.

ADAMANT WALL PLASTER.

In May, 1891, calcining works were started, the product of which is shipped to th Adamant mills in Toronto. These mills are at 100 Esplanade street east, having bee established in October, 1889, in connection with the company of the same name i Syracuse. Seven grades of adamant are manufactured here, the material being use instead of lime to plaster walls. It is a prepared mortar, put up in bags ready for u at any season of the year, and when water is added it is put on with a trowel in th ordinary way. It is mixed by machinery, so as to secure uniformity in the proportio of ingredients, and the manufacturers claim that four hours after application it is as har as marble.

The product of the mills last year was 15,000 bags, three-quarters of which consiste of 140 lb. bags for the first coat of plaster and one-quarter of 90 lb. bags for finishin The value of the output was $10,000.

MARTINDALE'S MINES AND WORKS.

Gypsum mines were worked more than fifty years ago on the right bank of the Gran river below the village of York, in the township of Oneida. The only one now worke is owned by Thomas Martindale, but there were three others lower down the rive A plaster mill in connection with one of these was erected by a Mr. Cook in 1838.

In 1846 or 1847 Thomas Martindale the elder opened a mine on his farm half mile below the village of York, on the opposite side of the river, and three or four yea later a saw mill in the village was converted into a plaster mill which is being run now the property of Thomas Martindale the younger. It has a capacity of fifteen tons per da if the water is high, but when the river is low it grinds only four or five tons per day.

The miller states that he came to the locality in 1840, and Cook's mines and the fir plaster mill were in operation then.

The Martindale mine is on the property of Frederick Martindale, but is worked b his brother Thomas. The rock is mined by the contract system, and under favorabl circumstances one man can take out seven or eight tons per day. The works extend under five fields of the farm.

The gypsum is carted to the mill where it is ground in the raw state and shipped to warehouses in Caledonia, Brantford and other neighboring towns and sold to farmers as land plaster.

THE CALEDONIA MINE.

The Caledonia mine is situated on lot 13 in the fifth concession of Oneida, and is the property of Mr. N. Garland of Toronto. Gypsum was discovered here by Mr. Joseph Brown, the former owner of the lot, while sinking a well for water, and about twenty years ago he sold it to Mr. Garland. Two acres was added from the lot on the opposite side of the highway and an opening was made where the ground slopes northward towards Mackenzie creek.

A shaft was driven southwestward under lot 13 and the mine was worked for fourteen years; but owing to the carelessness of the miners it filled in with soft clay for a length of thirty or forty yards, to remove which would cost more than to open a new mine.

A new shaft was accordingly commenced in June, 1887, about thirty rods south of the fifth concession road, the grade of which was one foot in nine through clay. The gypsum bed was struck at the end of eighty-six yards and the bottom of the bed at ninety-six yards, fifty-seven feet in perpendicular distance from the surface.

The cap rock is a soft limestone two to fifteen inches in thickness, and the depth of the gypsum bed ranges from four and a half to six feet.

At first the working in the gypsum was driven southward about twenty-five yards, the rock being mined laterally a width of three to ten yards, and about 1,000 tons taken out. This is near to the southerly limit of the property, and the timber supports having been taken out the overlying rock and earth cracked and sunk from the surface.

A side drift has been carried northwestward thirty-five yards with an average width of ten yards and about 2,500 tons of gypsum taken out. An escape and air shaft has been sunk from the surface to the main drift, 52 feet.

A tramroad is laid down the inclined shaft, and over it a horse draws out about one ton per load; the height is 5 feet 9 inches to the timbering, and the width 4 feet.

The mine is worked eight months in the year with four men under the contract system, who raise about six tons of assorted gypsum per day.

From the mine the gypsum is carted three miles to Caledonia, where it is ground into land plaster. This mill has been idle during the past year owing to a break in the dam across Grand river, but a new one is being erected in connection with a steam flouring mill at the railway station.

The area of Garland's gypsum field is computed to be six acres, but a well put down to a depth of sixty-two feet on an adjoining farm to the west shows the existence of a bed six feet in depth there.

ALABASTINE COMPANY OF PARIS.

The Alabastine Company of Paris was organised in 1885 with a capital of $50,000, of which $28,000 has been paid in. Its place of business is the old mill where land plaster has been ground for nearly seventy years, the gypsum having been supplied principally from the mines on the west bank of the Grand river, about a mile below the town of Paris, on the farms of Messrs. Miller and Martin, but the company has acquired the mining right [*]

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[*] The History of the County of Brant gives some account of the early history of gypsum mining and the manufacture of land plaster at Paris. Henry Capron, who founded the town of Paris, was born in Vermont in 1796, came to Canada in 1822 and joined Joseph Van Norman in the manufacture of pig iron from bog ore in the county of Norfolk. It was hard work, but Capron made money, sold out his interest in the iron furnace May 7, 1828, and visiting the Forks of the Grand river in 1829 he bought 1,000 acres of

The manufacture of alabastine was commenced in 1885 and plastico in 1889, under an American patent. Both materials are used in the finishing of walls, the former for tinting and the latter for tinting, stippling and heavy relief work Both also go through the same process of manufacture, but differ in the component materials for the production of relief work.

After the plaster is calcined it is run through a pair of patent French buhr stones where it is ground by attrition and mixed with colors, sizing, and (if intended for plastico) with the necessary ingredients to produce a relief effect. All parts are fed mechanically, so that exact proportions are always attained. Afterwards the compound goes through a screw mixer and is then ready for boxing.

The quantity of alabastine manufactured in a year is 75 to 100 tons, and the market for it extends from St. John, N.B., to Vancouver, B.C.

Plastico is only beginning to be known, but it appears likely to grow in demand where artistic finish finds favor. The chief difficulty experienced with its introduction, the manufacturers say, is in the procuring of workmen with the requisite taste and skill; but as the American patentee bought out the works of the company in November of last year it is not unlikely that this drawback will be overcome.

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land there from William Holmes. This included nearly all of the present site of Paris. In the same year he hired a Mr. Cushman, a wheelwright, to build a mill with two run of stones, one for grain and the other for plaster. This mill stood on the river Nith, a little way from the junction of that river with the Grand. One Charles Conklin was employed as manager, and at the end of 1830 he rented the mill from Capron and threw himself into the business with great energy and success, mining and grinding gypsum, making brick, etc. "The first mill for manufacturing gypsum was built in 1823 by William Holmes. From him it passed into the hands of Thomas W. Coleman. It is now worked by Gill, Allan & Co. of Paris" (p. 473). Mr. Gill has been employed in the works for twenty-nine years.

NATURAL GAS.

Natural gas is not a mineral of recent discovery. Its existence has been known for thousands of years in the old world, and in the new its discovery goes back at least as far as the earliest exploitations for salt in Pennsylvania and Virginia. But the extent and number of gas fields on this continent have become known for the most part in connection with the borings for petroleum, a mineral with which gas is now known to be intimately associated. It is more than thirty years since the first petroleum wells were bored in Pennsylvania, but although gas was obtained in many of them its value as an article of fuel only began to be recognized about ten years ago. During those ten years many wells have been put down in Pennsylvania solely for gas, the relations of the mineral to geological formations and conditions have been carefully studied, and as a result of the information gained in this way exploratory work has been undertaken in many other parts of America with varying success. Here in Ontario we have two fields whose limits are known in part, both on the north shore of lake Erie, but separated from each other by a distance of 150 miles. Excepting wood and petroleum it is the only natural fuel we possess—unless peat can be so claimed,—and as it is pretty generally recognized that the supply admits of being exhausted, no matter how plentiful it may seem to be, the question of economizing it and getting the best service out of it for our own uses is deserving of the most careful consideration.

THE ESSEX COUNTY GAS FIELD.

The Essex county gas field in Ontario owes its development to the discovery of gas about three years earlier in Hancock county in the state of Ohio. The preliminary report upon Petroleum and Natural Gas in Ohio by Prof. Edward Orton in 1886, in which was demonstrated the relations of the occurence of these products to the Cincinnati arch, had the effect of inducing an exploration of that portion of Essex which was known to be traversed by the same arch. This fold or anticlinal extends from Alabama through the states of Tennessee, Kentucky, Indiana and Ohio, under lake Erie and the western counties of Ontario and Manitoulin island, to the northern shore of lake Huron, and perhaps far beyond. In a paper on the Petroleum Field of Ontario read before the Royal Society of Canada in May, 1887, Dr. Robert Bell states that the anticlinal theory in connection with the accumulation of gas and petroleum was mentioned to him by Sir William Logan in 1860, who was then in the habit of comparing the filling of a soda water bottle with gas and water with the process which he believed went on under the impervious strata of an anticlinal; but Dr. Bell believes that the idea originated with Dr. Sterry Hunt.

According to this hypothesis gas and oil, following hydrostatic laws, accumulate at the highest points or the domes along anticlinal folds. All the transverse joints and fissures and the spaces or channels between beds in deep-seated, unaltered, sedimentary rocks are believed to be filled with water. The particles of gas and oil as they are generated or become liberated in bitumeniferous rocks naturally tend to rise through these waters, aided perhaps by earth-tremors and earthquake jars and rocks such as are common in Canada and the northern United States. Downward projections and irregularities in the forms of the water spaces would arrest the gas and oil till these receptacles became filled to overflowing. Ultimately the lighter fluids from all points, following upward the slopes of the strata, would accumulate in largest quantity under the summit of the dome. The gas would take the highest place, the oil the next, while the water would be forced downward to an extent which would counterbalance the elastic force of the gas and the weight of the accumulated petroleum. The compressed gas would force back the oil and water alike from all the upper spaces. If the crown of such an anticlinal dome were tapped by a bore-hole from above the gas would of course escape first, followed by the oil and then by the water. This is what actually takes place in productive oil regions, and experience in Canada, the United States, Galicia, Baku, Burma, etc., has shown that the accumulations of petroleum are connected with anticlinals in the manner just described. The more extensive the anticlinal, as to either breadth or depth, the greater are the quantities of gas and oil which become collected as the result of what may be called the larger drainage area. Profitable supplies of petroleum and gas are therefore not to be looked for on anticlinals of small extent.*

The Cincinnati arch has an exposed width of about 130 miles in Kentucky, where it is supposed to have reached its greatest elevation. At Cincinnati, in southwestern Ohio, its breadth is about 90 miles, and the rocks of the formation—the Cincinnati group, which are the equivalent of the Hudson River and Utica shales—are shown by surface exposures to cover almost the whole area of the basins of the Miami and Little Miami rivers. Thence northward to lake Erie, between Toledo and Sandusky, it narrows gradually and possesses a northerly as well as an easterly and a westerly dip, so that whereas in Highland county north of Cincinnati the surface is 500 feet above the level of the lake it is at the lake shore about 400 feet below.† And as the elevation of the Cincinnati axis occurred during the period between the Lower and Upper Silurian ages the difficulty of tracing it on the Ontario side of the lake is obvious. It could only be done, as in northern Ohio, after the records of numerous borings had been obtained. Logan and Hunt traced it by means of the distribution of the formations to the head of lake Ontario, running in an east and west line across the peninsula; but Dr. Bell by careful study has come to the conclusion that the arch maintains its northward course and runs into the southern extremity of lake Huron.

> The trend of its crown varies locally of course, but the geological distribution of the formations at the surface shows that this axis, coming northward from Kentucky and passing under the town of Findlay would strike the shore of lake Erie about midway between Toledo and Port Clinton, but in this vicinity the general wave is divided by a small synclinal into two subordinate anticlinals. Professor Orton has shown by the result of borings that the form of the Trenton area in northwestern Ohio, as indicated by a horizontal plane at 500 feet below the sea level, would prove that the axis at that depth points directly towards Toledo. Notwithstanding the difference in the courses of the deeply seated and surface folds, the main axis of the anticlinal will intersect the north shore of lake Erie in the vicinity of Little's point in the county of Essex; then running about north-northeast through Essex, Bothwell and Lambton, it will reach the southern shore of lake Huron near Kettle point. Its general bearing from lake Erie to lake Huron is about north 30° east, but it appears to curve gently to the southeast of a straight line and to pass under Petrolea. . . . The Cincinnati anticlinal in southwestern Ontario as elsewhere is a gentle swell of great breadth, but within its general area and especially near the summit are minor anticlinals sometimes of a sharper form, running both parallel with and transverse to its general course.‡

Knowledge of the course of the Cincinnati arch across Ontario was in this way clearly indicated, and it only needed the revelations of Prof. Orton's first report to infuse the hope that the conditions under which petroleum and natural gas were found at Findlay in Ohio obtained also along the line of the same arch in Ontario. The following extract from this report was itself an inspiration:

> The Trenton limestone is one of the most widely extended strata of the North American continent. It stretches from the islands north of Hudson bay to Alabama, and from Quebec to Minnesota. It has thousands of outcrops within these wide boundaries. It is known to be bituminous in New York; in Canada it yields a little oil; in Kentucky and Tennessee also it has been credited with oil and gas production; but it was a geological

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*Transactions of the Royal Society of Canada, vol. v. section IV. p. 103.

†Geological Survey of Ohio, vol. I. pp. 89-111. See also Report of 1890, in which Prof. Orton describes the bearing of the uplift as revealed by recent borings. It now appears that instead of pursuing a uniformly northeast course, as was formerly believed, the Cincinnati uplift bears to the northwest into Indiana, whence there is a northeasterly offshoot back into Ohio through Lima to Findlay which is 20 to 30 miles wide at its narrowest portion. "The structure at Findlay," Prof. Orton says, "is that of a well-marked monocline, descending to the westward, and often at the rate of one foot in eight, for 1,000 to 1,200 feet of horizontal distance. The break can be traced with perfect distinctness to the north of Findlay, passing a little westward of Van Buren, North Baltimore, Bowling Green, Monclova and Sylvania." (p. 48.) At Findlay the uplift bends abruptly and bears due north or a little west of north to the Michigan boundary, which it reaches near Sylvania. In Sandusky and Ottawa counties there is a two-forked axis of no great force which extends from the vicinity of Tremont northward to the shore of lake Erie, and this is probably the one which crosses over into Ontario. Prof. Orton now proposes to abandon the "Cincinnati group" in the geological nomenclature of Ohio, as a result of discoveries recently made in the underground geology of that state, and to revert to the old names of Utica shale and Hudson River group. (p. 15.)

‡Transactions of the Royal Society of Canada, vol. v. p. 107.

surprise when it was found to be a great storehouse of fossil power underneath the flat country of northern Ohio. It had already been tapped at various points in the state, and had given no sign of such contents. The drill had reached it at Eaton, at Cincinnati in numerous wells, at Columbus, and at a few other points, and in none of them had it given rise to even the suspicion of being heavily charged with oil or gas. The discovery of this new horizon is certainly one of the most remarkable and important discoveries in the geology of the state. The rock is already yielding many million feet of gas per day, of enormous value as a source of power. It is also producing 1,000 to 1,500 barrels of oil per day, and the development is going forward with great rapidity and with all the excitement that everywhere attends such exploitation. At least a half million dollars will have been spent in drilling wells in the new field by the close of the present year, according to present indications. Tankage on the large scale and pipe lines are being introduced into the chief centers of production, and in short all the familiar experiences in the opening of a new oil field are going forward here, with a Lower Silurian limestone that lies a thousand feet and more below the surface, and the nearest outcrops of which are 500 miles distant, as the base of operations. All this is a complete geological surprise. The practical driller has a maxim to the effect that "geology never filled a tank." Certainly geology takes no credit for the discovery of Trenton limestone oil and gas in northwestern Ohio.*

Encouraged by the success of borings for gas and oil on the Cincinnati arch at Findlay in Hancock county, Ohio, a number of local capitalists in the county of Essex undertook the task of exploiting that county over the continuation of the arch on the north shore of lake Erie, and the place chosen for the first test well was in the vicinity of Kingsville, in the township of South Gosfield.

KINGSVILLE NATURAL GAS AND OIL COMPANY.

The Kingsville Natural Gas and Oil Company was incorporated by letters patent October 3, 1890, the officers being Dr. S. A. King president, J. H. Smart vice-president, S. T. Copus secretary and Dr. E. Allworth treasurer. The capital stock is $40,000, all subscribed and one-ninth paid up.

The company was at first known as the Kingsville Citizens Natural Gas Association, and was formed in the latter part of 1888 to bore for gas and oil. It had its origin in this way :

The Ontario Natural Gas Company, of which Mr. Coste of Amherstburg was president, had in January, 1888, put down a well on the northwest corner of lot 7 in the first concession of Gosfield, the property of Mr. Wesley Wigle, and the council of Kingsville sought to make terms for the supply of gas. But owing to a dispute which arose between members of the company, and of legal proceedings which ensued, the president refused to make any arrangement with the village, although a pipe had been laid along the surface of the ground to light the streets, which was afterwards taken up. The service however had given the villagers a demonstration of the value of gas for the purposes of light and fuel, and the Citizens' Association was one of the results.

In May, 1889, the Association began to bore its No. 1 well near the lake shore, on the farm of Mr. Angus Wigle, lot 3 in the first concession. No oil or gas was obtained here, and although the failure was reported in August no further attempt to explore was made until the summer of 1890.

Meantime negotiations were re-opened with the Ontario Company, but they were fruitless; this company had leased every farm in the locality and felt secure in its ability to dictate terms. But the villagers found a way out.

In the spring of 1890 application was made to the township council for leave to bore on the public roads, and a lease was granted for this purpose for one year at the rental of $1, renewable for a term of four years at a rate of $50 per well. The location selected for the first boring (being No. 2 well of the Kingsville Co.) is at the crossing of the Wigle sideroad and the second concession line, seventy yards northwest of the Ontario Company's well, and embracing an area 110 feet long by 30 wide.

President Coste offered a vigorous opposition to this movement, and besides moving for an injunction to restrain the Association from proceeding to sink the well he took steps to quash the bylaw of the council under which the lease had been issued. Work was interrupted for two months until the injunction was dissolved by Justice Street, who held that gas was a mineral and therefore that the council was authorized by statute to lease the highway for mining purposes. This judgment was appealed, but in November, 1891, it was affirmed by the full court.*

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*Preliminary Report upon Petroleum and Inflammable Gas, by Professor Edward Orton, State Geologist, 1886, p. 30.

Boring was resumed after judgment had been given by Justice Street, and about the first of August, 1890, gas was struck at a depth of 1,025 feet in what is believed to be Clinton limestone. Gas was found in small quantity at 800 feet, as well as at frequent intervals lower down. On approaching the main reservoir it was observed to rise with a gradually increasing volume from 1,015 feet until boring ceased, and the flow became so strong as to eject water, oil and pieces of rock. The well was then allowed to flow for twelve hours with the object of testing the permanency of the supply.

The flow was found satisfactory and continues to be so, the so-called rock pressure being nearly 500 lb. An exhibition of the well's capacity is occasionally given to visitors, when a stand pipe is opened and the gas allowed to escape at its full volume. On such occasions the roar is so loud as to be distinctly heard in the village two and a half miles distant, and when the gas is lighted the flame shoots fifty or sixty feet into the air.

In beginning to bore a well a pipe eight inches in diameter is driven through the drift to the rock. This pipe is made of wrought iron with a steel shoe fitted on the lower end, and is put together in sections of twenty feet in length connected by screws; as each section is driven to the ground level another is screwed on, and so continued until the rock is reached. Boulders are often met with, but they are either broken or forced out of the way. The core of the drive pipe is spudded, watered and lifted with a sand pump, and on getting to the rock an 8-inch drill continues the boring to a depth of about six hundred feet when it is cased with 5⅝-inch casing to shut off water from the section of the well below. In this No. 2 well a strong vein of mineral water was struck at a depth of about three hundred feet—strongly sulphurous, but clear, sparkling and palatable. It is an artesian supply and flows out in an unintermittent stream between the drive pipe and casing. But for the latter it would run into the bore and destroy the value of the well as a gas producer.

When a well is bored and blown off a 3-inch iron tube is inserted in the casing to within about fifteen feet of the bottom, to the lowest section of which is attached a packer to prevent the escape of gas except through the tube. The packer here used is the Dresser, one segment of which is rubber and is distended by springs which hold it firmly in place. The insertion of the tube is attended with much difficulty as the men are often overcome by the gas, only to get relief when they are dragged out into pure air. But once the tube is placed and securely packed the gas rises freely through it to the service pipe, whence it is delivered to consumers after the pressure has been reduced by a system of regulators.

After the completion of the well in 1890 a 3-inch service pipe was laid to the eastern limits of the village, where the regulating station was constructed. The pressure of gas in the pipe is 470 lb., an estimate of its daily capacity being 9,000,000 cubic feet, and if there was not an effective way of reducing and controlling it so as to obtain a steady flow at low pressure it is obvious that the gas could not be used for domestic purposes at all with safety. But by means of regulators the high pressure at which the gas escapes from the well is brought easily under control. These are two in number, each consisting of a double valve acted upon by the pressure of gas on a diaphragm that raises and lowers a weighted lever to close or open the valves according to the force of the pressure. In its passage through the first regulator the gas is reduced to a pressure of 50 lb., and in the second to 2 or 3 lb., as may be desired.

To insure the free action of the regulators it was found necessary to keep the gas at a temperature above freezing point, but the first chamber constructed for this purpose at Kingsville was destroyed by the heating flame igniting the gas in the pipe. In the new one the pipe passes to the regulators through an outside brick pit, and is enclosed in a section of 8-inch drive pipe, the latter being heated by a gas flame which plays upon it and so maintains the required temperature of gas in the inner pipe. From this pit there is a current of hot air flowing to the regulating station and serves to keep it moderately warm, which is necessary for the free play of the parts of the regulators. An auxiliary pipe is provided in case of accident to the regulators, but it is connected with the main pipe at the west end of the village so as to provide for steady circulation. The supply pipe from the regulator house is four inches in diameter, and each consumer has his own regulator to govern pressure within certain limits, or in case of accident.

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*19 Ontario Reports p. 591, and 18 Ontario Appeal Reports p. 626.

Besides Kingsville to the west, the village of Ruthven to the east takes gas from this well for light and fuel; and so cheap and satisfactory is the supply that about nine-tenths of the dwellings, factories and places of business in both villages are patrons of it.

Well No. 3 was put down on the northeast corner of lot 4 in the first concession, about three-quarters of a mile west of No. 2. Work was commenced in October, 1890, and finished in January, 1891. The total depth reached was 1,114 feet, at which a strong vein of salt water was struck. At 700 feet a small flow of gas was obtained.

The Company's No. 4 well is located on the northwest corner of lot 7 in the first concession, about two hundred yards from the Ontario Company's well. Boring was commenced in the summer of 1891 and at first proceeded rapidly, the rock being reached at 116½ feet. The following particulars have been furnished by Mr. Copus, secretary of the company, under date of February 2nd, 1892.

> The work proceeded slowly for a time. This was due in the first place to the tools which were required having been missent from the American side; in the second place to the number of crevices which were struck at a depth of 400 feet in the rock, which gave the drillers much trouble, one being reported nine and another fourteen feet across; and in the third place to the mistake of trying to case the well before a sound casing rock was reached, the pipe having to be drawn out four or five different times. After the casing had been set properly the tools went down very rapidly, until in the month of December the well came in with a very fair flow of gas.
>
> The total depth of the hole is 1,068¼ feet. The gas was struck at 1,030 feet, but we went down in the hope that the flow might be increased. In this well we came across what has not been discovered in this field before; after passing through the gas rock we ran into pure chalk. This has not so far as I know been discovered in any of the other wells in this field. *
>
> At one time it looked as if the well would come in with oil, for there was a good showing, but it did not materialize.
>
> When the well was capped and anchored it showed 400 lb. rock pressure, but the volume only shows an output of 2,231,000 cubic feet per day according to the scale of computation used on the American side.
>
> I think we have every reason to congratulate ourselves so far on our works. During the past cold snap it has proved to our customers what a blessing gas is for domestic use. Of course the cold weather entails more vigilance on the part of the superintendent and men employed, for if anything should happen the line or regulating stations with the themometer below zero it would be a serious time with the householder who had no wood.
>
> As you know, we are supplying the village of Ruthven, a small place four miles east of us, and since you were here the line has been extended to the west, until at present we have upwards of ten miles of pipe line, with five reducing stations. The pipe lines vary from one to four inches. Our main high pressure line to Kingsville is three inches to the reducing station. After leaving the station the main low pressure line is four inches, from which different sized lines branch.
>
> In the village of Ruthven we carry from one-and-a-half to two pounds pressure. In Kingsville we carry from two to three pounds.
>
> We have about 850 cook-stoves attached, 175 heating stoves, 25 house furnaces, besides open grates, lights, etc. Then in addition to this we supply gas to the woollen mill, grist mill, sash and door factories, turning factory, grain elevator, the Mettawas summer resort, fruit drying establishment, the churches, halls, lodge rooms and many other places. It also furnishes the fuel for burning lime, the stone for which is brought here from Pelee island.
>
> Since the plant has been running we have not had to close down once for repairs or any other cause. This a pretty good showing when we see that such large companies as the one in Detroit and many others frequently have to turn the gas off from customers from one cause or other.

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* A sample of this rock which was sent to me by Mr. Copus has been identified by Prof. Coleman of the School of Practical Scicence as magnesian limestone.

In the month of October last the price of gas to consumers was increased 20 per cent. for all uses except indoor lights, and the following rates are now charged under contract:

To private houses.—Cook stove No. 5 mixer, $1.50 per month for whole year; heating stove $1.50 and furnace $2.40 per month of seven months; open grates where furnace is used 75c., and if furnace not used $1.50 per month of seven months.

To hotels.—Furnace No. 5 mixer, $3 and No. 7 $3.60 per month of seven months, and for cooking range $2.40 per month of twelve months.

To stores, offices, etc.—Heaters No. 5 mixer, $1.80 per month of seven months.

For indoor lights the rates are 16c. per month for one light, 14c. each for two, 12c. each for three and 10c. each for four or more.

Special rates are given to manufacturers, but although the fuel is cheap and abundant it does not appear to have yet brought any new or important industry into the locality.

The gas is wastefully used by consumers, the opinion seemingly prevailing that the store is inexhaustible. Street lamps are in some cases allowed to burn all day, perhaps because it is thought by the authorities to cost less to let the gas burn day and night than to turn it off in the morning and on in the evening. A number of the lamps are flambeau lights, whose flare at night when seen at a distance recalls the oldtime sight of burning log-heaps in the settler's clearing. The experience of gas-producing districts in the neighbouring state of Ohio, where like wastefulness was the rule a few years ago, might have taught the citizens of Kingsville a lesson in the economic use of natural gas. It is an excellent fuel, but the supply has limits in the richest fields, and in Gosfield the producing area as far as proved is very circumscribed.

BORINGS AT MARSHFIELD.

Several other wells have been bored in the Kingsville field, but gas has not been struck in any of them. In the township of South Colchester two deep wells were put down at Marshfield station by Hiram Walker of Walkerville. One sunk in February, 1890, to a depth of 1,040 feet, struck oil which was pumped for several weeks last year and yielded six barrels per day. Another well about fifty rods farther east was sunk to a depth of 1,300 feet and went through thirty-five feet of rock salt. Three wells were bored to supply water to flood a cranberry farm, one of which is a deep well on the north side of the farm. The other two wells are on the south side and water was struck in them at 160 feet, 80 feet in the rock; the water, which is impregnated with sulphur, flows in a strong and steady stream through a 4½-inch pipe when the tap is opened.

THE GAS FIELD OF FINDLAY, OHIO.

Having in view the collection of some facts on the economic uses of natural gas, I visited the town of Findlay, in Ohio, in the month of September. This town is 45 miles south of Toledo, on a plain 785 feet above the level of the sea and 212 feet above lake Erie. The underlying rock is limestone of the Niagara series, which is covered with Drift to a depth of ten or fifteen feet.

As far back as 1836 gas was found in the locality by a farmer who was digging a well for water. This strike was made at a depth of ten feet, and like experiences soon followed in other wells, but especially within the village limits of Findlay whenever the limestone floor of the country was reached, and where explosions frequently occurred in wells, sewers and other excavations by reason of the accumulation of gas. Gas was also noticed to escape constantly from springs flowing out of the limestone in the valleys of streams, and so general was it that considerable difficulty was found in getting a satisfactory supply of drinking water, owing to the presence of sulphureted hydrogen in the gas.

"There have always," says Prof. Orton, "been surface indications here of pronounced character, the most conspicuous of which are the sulphureted water of wells and springs, the escape of gas from springs and rock crevices, and its presence in numerous excavations that were carried down to the limestone rock."* And he adds that while the presence of gas was universally known, it was likewise universally deplored as a nuisance that must be endured because it could not be abated.

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* Eighth Annual Report of the U.S. Geological Survey, 1886-7, p. 523.

One of the villagers who dug a well with the usual result in 1838 resolved to turn the gas to some account, and used it to heat his house. He arranged an inverted sugar kettle in the well in such a way as to collect the gas, which was then conveyed through a wooden pipe to the sitting-room, where it was burned in an old gun barrel adapted to the purpose, and the fire thus lighted has been continued practically ever since. But of course those wells were all surface wells, and they yielded only a small supply.

The first person who is known to have recognised the larger possible value of Findlay gas, and to have set about devising schemes for developing and utilising it on any considerable scale, is Dr. Charles Oesterlin, an old and highly respected physician of the town. As early as 1862 Dr. Oesterlin made repeated efforts to interest his fellow-citizens in some means for accumulating the escaping gas in quantity enough to light the village streets at night. He experimented upon the gas springs, and gathered all the facts as to the presence of gas in the wells and other excavations in the neighborhood. There was no one however to second his sagacious plans, and nothing came from this discussion.*

In 1882 and 1883 the Pennsylvania gushers in the vicinity of Pittsburgh aroused an interest in many parts of Ohio where surface indications seemed to give promise of successful explorations, and many of the ventures turned out failures. Especially was this the case wherever borings were made in shale. A company organised in Findlay began to drill in September, 1884. The Drift was only eight feet in depth, and was followed by a series of nearly continuous solid limestone beds to a depth of 250 feet. The drill then entered a series of shales about 850 feet thick, and in boring through them gas was found at several horizons. About the middle of November the shale gave way to a solid and highly crystalline limestone rock at a depth of 1,092 feet, and this proved to be a reservoir of high-pressure gas. "As soon as the drill penetrated its surface," Prof. Orton says, "gas in large volume was set free, and the flow was increased for the next ten or twelve feet of descent. The gas was lighted, and its blaze at night illuminated a circle of country 20 miles in diameter. The Pioneer well was successful. A new horizon of gas and oil not dreamed of heretofore was brought to light, and Findlay became the centre and inspiration of a development of fossil power scarcely, if at all, inferior in value to the great petroleum reservoirs of western Pennsylvania and New York." Yet the volume of gas from this well was only 250,000 or 300,000 cubic feet per day. Many others have been bored since, some of which have yielded gas and some oil, and from a few the output has been enormous. And what surprised the geologists as much as anything else was the fact that both gas and oil were found in the Trenton limestone.

THE CITY GAS WORKS.

The Findlay Natural Gas Department is a branch of the city corporation, and the drilling and working of wells and the supply of gas to citizens for fuel and light is under its control. The first company, organised to bore the Pioneer well, sold out in a year to the Findlay Gas, Light and Coke Co., which put down sixteen wells, all within the corporation limits. In 1887 the second company sold to the city corporation, under which the work of development has been greatly extended. Forty additional wells have been put down in the corporation field and thirty-six outside, but all of them in the county of Hancock. Yet although so many wells have been drilled by the city, and many by the Standard Oil Trust and other companies, the gas area of the territory is not clearly defined, saving in this particular, that Main street divides the oil and gas territories, gas being got east of this street and oil west of it.

Every new well is a "wildcat" well.† It often happens indeed that wells bored in the close neighborhood of each other give very different results. For instance, a well 1,170 feet deep at Stewartsville, 3½ miles northeast of the court house, yielded 17,000,-

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* Eighth Annual Report of the U. S. Geological Survey, p. 523.

†The term "wildcat" is better understood in Ohio than in Ontario, and was originally applied to the banking system which devastated the Ohio states from 1837 to 1860, under which banks were enabled to issue large amounts of notes while possessing little or no capital. As now understood a wildcat scheme is any wild, reckless, haphazard venture; and applied to boring for gas or oil it is a business of "going it blind." One never knows what a well may bring forth; it may turn out to be a gusher, or only a dry hole,

000 cubic feet per day. The farmers of the locality organised a company of their ow and sunk a well to a depth of 1,200 feet, only thirty feet from the city well, and g nothing. But after torpedoing it a flow of 3,000,000 cubic feet per day was obtaine and having been put down to sell, it stood a year unused, when it was found to be charge with salt water and unproductive. The shattering of the rock by the shot had also t effect of reducing the capacity of the corporation well from 17,000,000 to 3,000,000 fe per day.

The producing territory controlled by the city occupies an area of several thousan acres, and 110 miles of pipes have been laid, including the field lines. The latter are si and eight-inch pipes, but it is proposed to lay down twelve-inch pipes instead, so as t reduce the friction. This is found to be necessary as the pressure of the gas is continuall diminishing, it having fallen from 400 lb. to a varying pressure of 200 to 300 lb. Fort wells have a daily capacity of 120,000,000 cubic feet, but the quantity consumed does no exceed 40,000,000 feet. A complete high pressure line surrounds the town, and the ga is delivered through low pressure regulators to fourteen supply lines at a pressure of 8 oz per square inch. If the mains were larger this pressure might be reduced to 4 oz. without impairing the efficiency of the supply, as with the higher pressure a quantity of th gas escapes without being consumed. But even with a pressure of 8 oz. private regulators are not required, for the pressure does not vary.

Among the industries which get their supply of fuel and light from the city wells ar fourteen glass factories, employing about 200 hands each, two rolling mills, eight machine shops and foundries, seven boiler works, fifteen planing mills and wood-working factories, besides the water works, electric light works, brick yards, quarries, limekilns, and cooking and heating stoves for almost every citizen.

As evidence of the growth of Findlay since the discovery of natural gas, it need only be said that its population grew from 4,500 in 1880 to 18,000 in 1890, and that a large number of new and substantial industries were established during the decade.

UNITED STATES GLASS CO.

The United States Glass Co., which is one of fourteen similar establishments, sank a well of its own at the outset of its career five years ago. The rock pressure at first was 440 lb., and its daily capacity was 6,000,000 feet. Now its capacity is only 1,000,000 feet per day, and the pressure is reduced to 150 lb. The daily consumption is about 600,000 feet. Other wells in the vicinity of this company's well are also falling off steadily.

FINDLAY ROLLING MILLS CO.

The Findlay Rolling Mills Co. formerly carried on its business in the eastern part of Ohio, but was induced to remove to Findlay shortly after the discovery of natural gas there. Gas was supplied to the works at the rate of $200 per month, which, as compared with the company's former payment for fuel, was practically a free grant. But in the course of time the rate was increased to $1,460 per month, and the company then undertook to procure its own supply. This was done by boring seven wells about two years ago at a cost of $1,000 each, whose aggregate capacity is 15,000,000 feet per day, and pressure and supply do not appear to have fallen off since they were opened. There is no way of determining the daily consumption of the works, the only limit being the quantity required. There are nineteen puddling furnaces and one steel furnace whose daily product is fifty tons of muck iron and ten tons of steel. Four heating furnaces are required for the rolling mills and in forging iron which is manufactured into chains; the output of the latter is ten tons per day, and gas is the only fuel used except in heating the iron for two-inch cables. A plant of the same capacity would consume $30,000 worth of coal fuel in a year.

THE STANDARD OIL TRUST.

The Standard Oil Trust, working under the name of the Northwestern Co., was early in the Findlay field as a producer, and it has secured a territory which embraces several townships. For this land it pays a rent ranging from 50c. to $20 per acre; but where it could buy outright in good localities it has preferred doing so at prices ranging from $50 to $150 per acre. This company supplies outside places only, and it has pipe lines laid to Tiffin, Fostoria, Toledo and Detroit, the last named city 105 miles distant.

DRIFT GAS IN KENT COUNTY.

In many parts of Kent county natural gas has been found in the deep glacial Drift during the last thirty years, but more particularly along the base and on both sides of the high ridge which extends in a southwesterly direction through the townships of Orford, Howard and Harwich, and reaches the shore of lake Erie in the latter township about three miles west of Blenheim. Numerous borings were made in this district during the period of oil excitement at Bothwell, and although no petroleum was discovered at any point along or near the ridge several wells gave surprising yields of gas from the sand beds of the Drift. It is not at all likely that the gas had its origin in these beds, and no portion of the Drift below them is likely to have yielded it, assuming that gas is a product of organic matter, for as far as observations have been made there are no signs of animal or vegetable life having subsisted in the region during the deposition of the lower beds. The probability is that here as well as in Ohio the gas escaped from some of the older formations and was stored in the sandbeds of the Drift, which are usually overlaid with beds of hardpan or clay. Natural gas is found in greater or less quantity in all formations of the Silurian and Devonian series, where the nature of the rock allows it to accumulate; but unless the overlying rocks are close and compact the gas may have escaped into the atmosphere as fast as it was generated, or whenever earthquake or other disturbances have produced openings for its escape. The existence of surface gas is not therefore a sure sign that a large body of it may be found somewhere in the older formations; it is an evidence rather that vents have occurred by means of which the reservoir has been tapped and wasted. Yet at Findlay, in Ohio, this was not found to be the case, and there is a possibility that at some point in the county of Kent a store of natural gas exists in the deep underlying limestones. This also is to be borne in mind, that there are more "dry-holes" than producing wells in the Findlay field, whereas within the area of a hundred square miles in Kent over which surface shows have been obtained only one deep boring has been made.

BORINGS IN ORFORD.

After the dispute which occurred between the officers and directors of the Ontario Natural Gas Co., and which resulted in the closing down of that company's well at Kingsville, the Messrs. Walker were led to undertake prospecting work in the eastern part of Kent, in the vicinity of the Bothwell oil field. Mr. J. A. McKellar, agent of the Traders' Bank at Ridgetown, took an active part in this enterprise, and through his exertions a large number of farms were leased in the townships of Orford, Howard and Harwich. Two deep wells were bored in 1890.

DEEP WELLS NEAR THE THAMES RIVER.

The first of these wells was put down on the southeast corner of lot 10 in the eleventh concession of Orford, 2½ miles south of the river Thames. An 8-inch pipe was driven 160 feet to the rock. At 585 feet fresh water was struck and sulphur water at 630 feet. When a depth of 915 feet was reached a 5⅝-inch casing was put down to shut off the water, but a second flow of sulphur water was met with at 1,000 feet which rose in the pipe 100 feet, and at this point the drilling was discontinued. Following is the record as given by Mr. McKellar:

		Thickness.	Depth.
Soil, quicksand and gravel.	feet	160	160
Broken limestone, gray.		81	241
White shale or slate.		70	311
Limestone, gray.		90	401
Fossil limestone, pink.		154	555
Fine sandstone, white		30	585
Fine sandstone, gray.		45	630
Fossil limestone, pink to gray.		285	915
Fine sandstone, yellow.		85	1,000

A small show of oil was obtained in the first bed of fossil limestone, a rock whi from being full of shells the drillers called clover-seed. The first flow of sulphur wat was found in the white sandstone, but none of the beds gave a sign of gas.

The second well was bored on the east half of lot 23 in the fourteenth concession Orford, half a mile from the Thames. Here the depth of the Drift was found to be 2 feet, through which an 8-inch pipe was driven. Following is the record as furnished Mr. Walker from the driller's report:

	Thickness.	Depth.
Soil, quicksand and clay	feet 240	240
Limestone, gray	70	310
Limestone, pink	100	410
Limestone, gray	160	570
Shale, dark	2	572
Limestone, gray to black	628	1,200
Shale, black	3	1,203
Limestone, gray	60	1,263
Slate or shale, white	237	1,500
Limestone, gray	10	1,510
Salt, clear white	171	1,681
Limestone, pink	19	1,700
Limestone, gray	240	1,940
Shale, black	48	1,988
Limestone, gray and pink	212	2,200

Oil and water were found in the upper beds of limestone to a depth of 400 feet, an a small showing of oil again free from sulphur in the pink limestone at 1,681 to 1,70 feet. The bed of salt is of unusual thickness for the Ontario district, and being free fro water it might be mined to good advantage if a shaft were sunk upon it, as is now bein done in the state of New York, if the water in the upper limestone could be shut off o controlled. The driller reports that salt water occurred at intervals of a few feet in th lowest bed of limestone, and as he considered it would be useless to go deeper for gas o oil the well was abandoned.

The first of these wells is about four miles and the second about seven miles north the ridge.

SURFACE WELLS ON THE RIDGE.

On the south side of the ridge in the same township a well was bored in 186 which yielded a heavy flow of gas. It is on the farm of Mr. Jacob Limberger, lot 2 south Middle road, 3½ miles from lake Erie. Mr. Limberger had hired a man to sink a well f water, and the place chosen was within a few feet of the northern side of his house and nea to a small creek. The bore was ten or twelve inches in diameter and was cased with wooden pipe. At a depth of 100 feet the drill suddenly dropped about four feet in what wa supposed to be a bed of quicksand. A strong flow of gas then rose, and water, sand an stones were thrown out to a height of 40 or 50 feet above the surface. This continue for twelve hours, covering an area of two or three acres with mud and starting a stream water in the creek, and a loud roaring noise was heard which gradually subsided as the flo slackened. The stones were ejected with such a force as to cut off one of the posts of th derrick six or seven inches in diameter. The pipe was slowly filled with sand and mud but the gas continued to escape from the well for six or seven years, being most noticeabl when the wind blew from the east. "I often heard it at night," one of the neighbor said, "like the rumble of a wagon across the bridge." Owing to the nearness of th well to the house no test of the burning qualities of the gas was made.

On the farm of Walter Guyitt, lot 63 north of Talbot road, a mile north of lak Erie and south of the ridge, three wells were bored in the Drift in 1889. The firs struck a flow of gas at 180 feet, and the second struck gas at 160 feet; both were fille up. The third well, some 200 yards farther north, struck gas and water at 140 feet, an upon a light being applied the gas flamed to the top of the derrick. The gas still con tinues to flow from this well, especially when the water has been pumped for some tim to relieve the pressure or when the wind blows in a certain direction. The water i always riled.

On William Coleridge's farm, lot 66 south of Talbot road, a well sunk to a depth o

170 feet yields an abundant supply of water when pumped by windmill power. The water is of a slight milky color at first and is seen to be full of gas bubbles, but clears very quickly when exposed to the air.

BORINGS IN HOWARD.

On the farm of Duncan Campbell, lot 6 on the sixth concession of Howard, and about two miles north of the ridge, a well was put down in 1889. At 72 feet water and gas were struck, and water, sand and stones were thrown up to a height of 30 or 40 feet. This continued for sixty hours, during which the smell of gas in the vicinity was sickening. A pipe was then inserted in the well when the flow of water and mud was renewed and lasted for a day. The water subsided for a time, but the roar of the escaping gas was maintained for five or six weeks. It is now a flowing well, but the water is discolored and unfit for use. Gas bubbles up intermittently, being strongest when an east wind prevails.

Four wells were bored some thirty years ago on the farm of David Hamil, lot 14 on the west townline of Howard, all of which have yielded gas. One is 630 feet deep, at which a rock was encountered so hard that the drill could make no headway upon it. It is now a flowing well and yields a little gas. A second was bored 30 feet to the northwest of the first, and water and gas were struck in it at 70 feet; the gas still flows strongly when the wind is in a particular direction. A third well a hundred yards to the southwest struck a flow of gas at 70 feet, the last 30 feet of which was bored with a three-inch auger. It was afterwards filled up, but the gas continued to rise through the earth and for three years it was used for cooking purposes, when it is supposed the ground became packed so hard that it ceased to escape. The fourth well was put down at a hotel about a hundred yards north of the third, having been dug 20 feet and bored with an auger a further depth of 50 feet. The well-digger was smothered by the flow of gas, and two other men nearly lost their lives in the vain effort to rescue him. Water, stones and mud were thrown up to a height of 40 or 50 feet, and this exhibition continued for a week, when it is supposed the bore became filled. It is found here that a hardpan six to eighteen inches in thickness overlies the gas sand, under which is a bed of soft putty-like clay five or six feet in thickness; but in some cases the gas is found in quicksand under the clay. Almost all the wells in this neighborhood give indications of the presence of gas.

BORINGS IN HARWICH.

On the Harwich side of the townline a peculiar deposit is found which is locally known by the names of "Indian soap" and "gum bed." It occurs over a small area in sandy soil, is of a black color and foul odour and is found in irregular seams and pockets in the Drift. A boring has been made on this spot since the time of my visit, and Mr. McKellar informs me that at a depth of 50 feet a flow of gas has been struck stronger than that of any other well in the district. When lighted at night the flame rose 40 feet into the air, and the illumination was observed at a distance of ten miles. The deposit referred to is on the farm of Allen Sutherland.

In May, 1890, William Mead of lot 16 in the eighth concession bored a well on his farm for water. At a depth of 60 feet gas was found and water at 75 feet, but the boring was continued through the sand to the rock at 120 feet. A 3½-inch iron pipe was put down to the rock, but it soon choked with the fine sand. The gas escaped outside of the pipe and made an excavation at the surface four feet in depth and as many in diameter. The pipe was then taken out and a section 60 feet in length was put down instead, the lower end of it reaching to the sand bed. The roar of the escaping gas could be heard at the distance of a mile, and the pressure now does not show any apparent diminution. In July, 1890, Mr. Mead connected the well with his house and has since been using the gas for fuel and light. Several other wells have been bored in the same neighborhood, but gas has only been struck in two of them.

A well was bored on the gravel road six miles north of Blenheim twelve or fifteen years ago, at the Vestor house. A flow of gas was struck which exploded while a man was in the act of lighting his pipe, and the hotel was burnt. Two wells were bored in the same locality last year (1891), but no sign of gas was discovered in them.*

GAS FUEL FOR BURNING LIME.

Samuel L. Hartford is carrying on the business of lime-making in the Shrewsbury town plot south of Blenheim, where for the last three years he has been burning Pelee island limestone in a kiln of sixty barrels daily capacity. Until September of last year he used wood fuel, burning four cords per day, which cost delivered $1.50 per cord. Gas having a few months previously been discovered on Mr. William Muckle's farm in the same neighborhood, Hartford gave a contract for a well to be drilled on his premises. Work was commenced September 5th, and on September 7th gas was struck at the rock, at the depth of 107 feet. The drilling was continued in shale to 114 feet, when a two-inch pipe was inserted and connection was made with the kiln. The new fuel was found to answer the purpose quite as well as the old, and it saved the lime burner $6 per day.†

GAS SPRINGS IN LAKE ERIE.

Gas springs in the lake are a novelty. Two of them are found opposite the farm of Mr. James Claus, lot 4 in the fourth concession west of Communication road. "For twenty years," Mr. Claus said, "I have known of a spring of gas in lake Erie opposite my house, forty rods from the shore and in twenty feet of water. It bubbles up there continually, seed-time and harvest, making a commotion in the water eight or ten feet in diameter I should think. At different times we have gathered the gas there, but once in particular in the spring of this year (1891) when the boys went out and held a tub over the spring until it was filled. Then the tub was towed into the shore and when a plug was taken out of the bottom a match was applied and the gas burnt with a yellow flame for fifteen minutes. There is a smaller spring in four feet of water fifteen or twenty feet from the shore. There in the winter time it may be seen coming through a crack in the ice, and we have often lighted it." These facts are some evidence of the permanency of the supply of natural gas in the region. Mr. Claus went on to say that he had put down no well on his farm, as he takes water from the lake, but two wells had been bored on an adjoining farm about a hundred yards apart to the depth of 126 feet, and a strong flow of gas was found in each. No use is made of the gas as the owner does not live on the farm.‡

A DEEP WELL AT BLENHEIM.

In the summer of 1889 a company was organised at Blenheim to explore for gas, with a capital of $2,500 subscribed, subject to calls. A contract was made with a party from Findlay, Ohio, to drill a well to a depth of 1,200 feet for $1,500, and to a further depth of 300 feet if desired at $1.50 per foot, the contractors to put down an 8-inch drive pipe to the rock and 5⅝-inch casing to shut off water; but in the event of salt water being reached at a lower depth the company would furnish the inner casing. The location chosen was on the crown of the ridge at the west end of the village, where the bed rock was found at 205 feet. After passing through ten or twelve feet of gravel the Drift was found to consist of a tough clay, and under it various beds of shale, limestone and sandstone were passed through to a depth of 1,200 feet. A light flow of gas was struck at 300 feet, which burnt with a red flame. At 625 feet a vein of mineral water was tapped which rose in the well to within 100 feet of the surface. The drillers also professed to have struck salt water at about 1,100 feet, and claimed that by the terms of the contract the company should supply the casing to shut it off. A dispute arose, and soon afterwards the tools were lost in the well and the work was abandoned by the contractors. This I believe is the only deep boring hitherto made on or near the Kent ridge.

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*These are the wells put down to furnish a water supply for the town of Chatham, and which are referred to on p. 57.

†Dr. Samson of Blenheim. to whom I am indebted for valuable assistance in procuring information in this district, informs me that several other wells have since been obtained in Harwich. A very good one has been bored about a mile west of Hartford's, and another near Weldon station on the Canada Southern Railway. The last mentioned yields gas from a bed of dry sand, at a depth of 60 feet.

‡"In parts of Ontario, where I have studied the occurrence of petroleum, I have repeatedly noticed in association with it a large quantity of inflammable gas; and far to the east of that we find this gas as low down as the horizon of the Trenton limestone. I can mention three or four cases near Montreal where it is produced. That gas has been since the days of the old French colonists an object of interest and attraction. It has been gathered and used occasionally for illuminating purposes, rather as a curiosity than otherwise. There is a discharge of the gas also in the St. Lawrence. A considerable amount is constantly discharged in that river, keeping the waters in ebullition. There is another place on the north side of the St. Lawrence, at St. Leon, and another on the Ottawa, where the gas is discharged. These three cases in which the gas rises through the Trenton limestone, and other cases where it comes from the shales immediately overlying, are illustrations of the wide distribution of this natural gas and of its low geological horizon."—Dr. Sterry Hunt, Trans. Am. Inst. M.E. vol. XIII. p. 782. Referring to the occurrence of Drift-gas reservoirs in the district between Montreal and Quebec Mr. C. A. Ashburner of the Pennsylvania Geological Survey says: "It might be well to state that nowhere in America has Drift-gas been found in quantities which could be profitably drilled for and utilized, except in some sections of Illinois; and even there the quantity of gas is so limited that it can only be profitably utilized for domestic illumination and heating in the immediate vicinity of the wells."—Trans. Am. Inst. M. E. vol. XVIII. p. 293.

EXPERIENCES OF WELL-BORERS.

Peter Fleming lives on lot 16 of the west townline range in Howard, and is by occupation a farmer and well-digger. During the past two years he has been pretty constantly employed in putting down wells for water. He has bored about a hundred in Howard north of the ridge, chiefly on the fourth, fifth, sixth and seventh concessions, thirteen of which have yielded gas. In Harwich he has bored ten wells, four of which have produced gas. Water and gas he says are struck at depths ranging usually from 48 to 63 feet; but the nearer the ridge is approached the deeper the well, and the same observation applies in the direction of the Orford line—the one nearest that line having a depth of 86 feet. In every case but one gas and water were found above the hardpan. The Drift is mostly blue clay containing grit until a bed of putty-like clay about four feet in thickness is reached, below which is a bed of sand or gravel in which the water and gas are found. The volume of gas varies in the wells; in some a blue puff is observed when the containing bed is reached, and when the water comes the flow of gas ceases. In others a volume of water, sand and mud is thrown up to a height of perhaps 100 feet, varying according to the pressure. At the well on the farm of Duncan Campbell lumps of clay were ejected nearly a foot in diameter, and one stone more than six inches diameter; it was a smooth limestone boulder. The tools, weighing 1,300 lb., were thrown from the bottom of this well to the surface. The gas flowed from Thursday at 1 p.m. to Sunday at 1 a.m. In other wells the flow lasts from one to three days, and in a few cases the gurgling noise of the escaping gas appears to be permanent. As long as the gas continues to rise the water is of a milky color, but cattle are fond of it. The gas burns with a pale red flame and has a disagreeable odor.

Mr. T. C. Leper is also by occupation a well-digger and a large number of wells have been bored by him for water in the counties of Kent, Elgin and Middlesex. Two wells were drilled on the townline between Harwich and Raleigh, a mile north of the village of Buckhorn, on the north side of the ridge. Gas of 20 lb. pressure was obtained at 160 feet in a bed of course gravel under hardpan, and after shutting it off water was got at 175 feet. At William Muckle's farm, 4½ miles south of Blenheim and within a mile of Rondeau, gas was struck about the first of May at 114 feet, the pressure of which was found to be 47 lb. as measured by a steam gauge. At Hartford's lime kiln in the same vicinity, to which reference has already been made, gas was found at the same depth, but the pressure was not measured. At the fair ground in Blenheim water was found at 196 feet, with only a small show of gas At John Gordon's, in the Guild's settlement, a pocket of gas was tapped which blew out in a week. At Guild's school house three holes were bored before water was obtained, the deepest of which was 172 feet. One bored to 135 feet yielded gas, but the pressure was very light. At Ransome's school house on the Communication road a well 135 feet deep yielded artesian water and gas. The greatest depth attained on the south side of the ridge was on the farm of Mr. James English on the Communication road, where a well was bored to 170 feet, 42 feet in rock. Gas and water were found in this boring and the water rises within eight feet of the surface. On the sixteenth concession of Raleigh, on the north side of the ridge, water was found under hard pan at a depth of 200 feet. The best show of gas in this district is found in wells drilled in the vicinity of Rondeau harbor. Mr. Leper has bored for water at London and St. Thomas, the greatest depth of which is 130 feet, but no show of gas has been obtained. Three wells bored at the village of Union, south of St. Thomas, to a depth of 70 feet, yield a steady flow of water.

THE HALDIMAND AND WELLAND FIELD.

The largest area of gas-producing territory yet explored in Ontario is in the counties of Haldimand and Welland. It extends from the Grand river at Cayuga to the village of Bertie near the Niagara, a distance of about 42 miles. The producing belt ranges from one to two miles in breadth, and lies nearly parallel with lake Erie; but, as in all other fields, a great deal of uncertainty attends the enterprise of boring for gas. Some of the wells prove to be "gushers," and others only "dry holes." The gas is found about 200 feet nearer the surface than in the Essex field or at Findlay in Ohio, and generally in the Medina sandstone. But although the supply is abundant no large quantities are consumed in the field; the bulk of the gas is piped to Buffalo, where it is used as fuel. There is however some likelihood of glass works being established at or near Port Colborne this year.

THE PORT COLBORNE DISTRICT.

Natural gas has been known to exist in the vicinity of Port Colborne for a quarter of a century. Surface indications have been found there and at various other localities, especially in Welland county, but until the discovery and utilization of gas in Pennsylvania and Ohio no one seems to have heeded either the surface signs or the results obtained by deep borings. In 1886 exploration work began, but it was not until 1889 that capitalists were encouraged to invest on a large scale.

THE JEFFERSON STEELE WELL.

In 1866 a well was bored for oil on the farm of Mr. Jefferson Steele, (lot 31 in the first concession of Humberstone) a mile west of the railway station, and gas and mineral water were struck at various depths; but at that time mineral gas was not appreciated for either fuel or light, and the discovery created interest only as a curiosity. The tools were lost in the bottom of the well, and as the water was thrown up with great force the work of sinking for oil was abandoned.

Mr. Steele informed me that sulphur gas was met with at a depth of 420 feet, and at between 600 and 700 feet a vein of water was struck the pressure of which was so great as to throw a column above the top of the derrick, 45 feet high. The water continued to flow in this way for two weeks, so that boring had to be suspended; but at the end of that time it subsided and became irregular, spouting forth four, five or six times a day. The drillers were enabled to resume work however, as a gush of water was always preceded by a warning gurgle, and they sank the well to a depth of 820 (some say 840) feet when the tools were lost.

The intermittent flow has kept on to the present time, but with no regularity. Occasionally the pressure is very strong. A pipe of 1¼-inch diameter which had been put down to a depth of 500 feet and weighted with a heavy beam of timber was in the winter of 1890-1 forced up four or five feet and a column of water was thrown 40 feet into the air.

Three years ago Mr. Steele piped the well for the purpose of supplying his own house and the houses of several neighbors with fuel, and in the summer of 1890 the line was extended to the camp of summer cottages at Solid Comfort on the lake shore. But during the winter the supply fell off, and although the 1¼-inch pipe was replaced by a ¾-inch one the use of gas was discontinued in the summer of 1891, resulting it seems likely from the drain upon the rock reservoir by the opening of numerous other wells in the district. That the chief supply was from the lower formation was proven by inserting the pipe below the vein of sulphur gas and packing it so as to shut off the latter. The gas was separated from the water by means of tanks into which the water flowed, and was thence conveyed to the service pipe; but the whole contrivance was of a pioneer character.

The water is now allowed to escape from the ¾-inch pipe, but the flow is unsteady—at times ceasing entirely for two or three seconds, and again pouring out at the full volume of the pipe. When a match is applied the gas burns with a nice flame; but the gas is as inconstant as the water, and seemingly the one is in no way dependent on the other. For four or five seconds a light may be applied to the mouth of the pipe and no gas is consumed, and then the gas ignites and burns for some time whether the pipe is flowing its full capacity of water or none at all. The water is said to possess medicinal qualities, and to be especially valuable in kidney diseases.

THE PORT COLBORNE GAS LIGHT AND FUEL COMPANY.

The first company to bore for natural gas in Canada was the Port Colborne Gas Light and Fuel Co., and was organised by Mr. Cornelius O'Neal of Port Colborne in 1885. There were ten shareholders, and they expended about $6,000 in sinking a deep well in the village, about 400 yards west of the Welland canal.

The total depth of the boring was 1,500 feet, the last 700 feet of which was in red shale. At 1,230 feet the tools were lost, and to recover them cost $1,000.

Gas in small quantity was struck between 40 and 50 feet and sulphur gas at 432 feet. At 455 feet salt water was met with, which spouted up to a height of 50 feet in the air. The well was then cased in an imperfect way and the boring continued.

At 763 feet, Mr. O'Neal says, a hard rock was struck which at a depth of 25 feet yielded a good flow of gas. This burned with a 6-foot flame from a 2-inch pipe, and although the water interfered with the supply there was sufficient to furnish the customs house, the railway station and a number of other places in the village until the Port Colborne Co. piped the Humberstone district three years afterwards and put in a service for the village.

The well had a capacity of 7,000 cubic feet per day by tank measure, and when the gas is allowed to accumulate it still flows at good pressure for half an hour.

OTHER WELLS IN PORT COLBORNE.

A second well was bored in Port Colborne in 1886, in rear of Noble's drug store, by Mr. Samuel Hopkins. At 773 feet a light flow of gas was struck, but the water had not been properly shut off and boring was discontinued.

In the same year Matthew Richardson put down a well on his own lot on the east side of the canal, a quarter of a mile due east of the O'Neal company's well, to a depth of 770 feet. A small flow of gas was obtained in the red Medina sandstone at 763 feet. At first the yield was about 16,000 cubic feet per day, but it is not so great now.

In 1890 Mr. Henry Oronmiller drilled a well on the Charles Steele farm just west of the village to a depth of 800 feet, but only a light flow of gas was obtained.*

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* In the proceedings of the Canadian Institute, vol. XXIV. pp. 338-9, John C. M'Rae of Port Colborne furnishes the following record of the geological formation at that village as shown by drilling for natural gas: Commencing at a spot 12 feet above lake Erie level. the following strata were penetrated by the drill—

Corniferous	1 to	12	feet	Drift.
	12 to	25	"	Corniferous limestone.
	25 to	32	"	Onondaga limestone.
Lower Helderberg	32 to	35	"	Fair cement rock.
Salina	35 to	52	"	Shale and cement rock.
	52 to	60	"	Dark shale.
	60 to	90	"	Shale and cement rock.
	90 to	100	"	Gypsum and shale.
	100 to	107	"	Shale.
	107 to	147	"	Gypsum and shale.
	147 to	152	"	Shale.
	152 to	180	"	Shaly limestone.
	180 to	186	"	Drab colored limestone.
	186 to	190	"	Shaly limestone.
	190 to	302	"	Gypsum and shaly limestone, with transparent particles of *selenite* (?)
	302 to	500	"	Magnesian limestone.
	500 to	700	"	Shaly limestone.
Clinton	700 to	720	"	Clinton limestone.
	720 to	730	"	Clinton shale.

THE HUMBERSTONE DISTRICT.

The village of Humberstone is on the Welland canal a mile north of Port Colborne. Here a number of wells have been bored, and where gas has been found the flow is much greater and the pressure stronger than at Port Colborne.

NEAR'S WELL.

In the summer of 1890 Edward B. Near drilled a well in the west end of the village which was completed on the 2nd of July.

Limestone crops out at the surface in this locality and has a total depth of nearly 700 feet. Fresh water was cased off at 285 feet. Between 508 and 556 feet salt water was found, and this was cased off at 640 feet. At 683 feet the Clinton formation was reached and ten feet of that rock yielded gas. Red Medina sandstone according to the record of the boring occurred from 713 to 760 feet, followed by ten feet of slate or shale; gas sand from 770 to 780, slate from 780 to 815, white Medina from 815 to 822, and thence to 847 feet red shale.

The greatest flow was obtained at 683 feet, and at first the daily yield was computed at 500,000 cubic feet, with a pressure of 375 lb.

Service pipes were put in during the month of August, and 90 houses were supplied with gas for light and fuel during the first winter. Neff & Son's foundry also use it for fuel, and the Ontario Silver Co's. plating works take 1,000 feet per day; but the latter company procures its chief supply from the Natural Gas Co. and holds the Near well as a reserve.

The rate for cooking stoves is $12 a year, for heaters $1.50 per month for six months, and for a light 15 cents per month.

In October of 1891 there were 105 houses supplied by this well, and the pressure at that time with the maximum of consumption was 300 lb. It is delivered to consumers at a pressure reduced to 6 oz.

THE MORNINGSTAR WELL.

On the east side of the canal, fifty yards above the bridge, a well was bored in February, 1891, known as the Morningstar.

A flow of fresh water was found in the rock at a depth of 30 feet and salt water at about 400, but the well was drilled to 613 feet before it was cased. Gas was found in a bed of so-called sandstone at 666 feet, and a light flow in the white Medina at 798 feet.

The total depth of the well is 830 feet, and the total cost was $2,300. It is now sealed.

Medina	730 to 750 feet	Red shale, soft at first but gradually becoming harder.
	750 to 780 " ...	Red sandstone, mottled.
	780 to 833 "	Sandstone, red and white.
	833 to 1,500 "	Soft red shale, with bands of gray and green.

The Corniferous limestone here has a dip of 15 feet to the mile, and at Fredonia, New York state, 40 miles south of Port Colborne, it is not found until the drill has penetrated over 900 feet, so that further south a stronger dip prevails. The Niagara limestone outcrops 17½ miles north of Port Colborne, and, I am informed, has a dip of about 50 feet to the mile. Accordingly, we should find it at a depth of 875 feet, but we did not, as we had the Medina from 833 feet down to 1,500. Allowing that the dip is too great, it should be found between six and seven hundred feet; but so far I have been unable to find limestone which could be definitely assigned to the Niagara, and it was not until the second well was drilled that I obtained any limestone characteristic of the Clinton, to which Mr. E. Orton, state geologist of Ohio, to whom I am indebted for examining a series of samples, assigns the limestone found at 700 to 720 feet. At first not finding any limestone characteristic of the Niagara or Clinton, I thought that the whole stratum from the lower Helderberg to 1,500 feet was the Salina, and that the red shale was the lower part, but the finding of Clinton limestone shows that this was an error. Permanent water was found at 26 feet. Salt water at 452 feet. A fair flow of gas at 454 feet with a strong odor of sulphureted hydrogon. At 764½ feet the present supply was found which is almost odorless. The well was drilled to 1,500 feet, but there was no increase in the quantity of gas. The accurate flow of the well has not been estimated, but on its being closed for seven hours the hydraulic gauge registered 275 pounds, and was still going up. The gas is used both for light and fuel and gives satisfaction.

On George Zimmerman's farm two miles east of Humberstone, a well was bored by a syndicate where a small flow of gas has been obtained. It is not used.

PORT COLBORNE MUTUAL NATURAL GAS CO.

The Mutual Natural Gas Co. of Port Colborne was organised in March, 1891, with an authorised capital of $20.000, of which $14,000 has been subscribed and paid up.

The object of this company is to supply fuel for domestic and manufacturing purposes in the villages of Port Colborne and Humberstone, but all efforts to bring in manufacturers have so far failed.

The company has bored two wells and leased one in the township of Humberstone, northwest of the village of Port Colborne.

The first one is in the northeast corner of lot 29 in the first concession, and was put down to a depth of 831 feet, finishing in the Medina shale. A small flow of gas was got at 685 feet, which is computed at 100,000 cubic feet per day.

The second well is northwest of the first, on lot 29 of the second concession, and was bored to a depth of 705 feet at a cost of $1.70 per foot exclusive of casing pipe. Water was cased off at 630 feet, and gas was struck in fine sand at 690 feet, the bed continuing to yield down to the bottom of the well. The pressure is 365 lb. and the yield per day is estimated at 1,500,000 to 2,000,000 cubic feet.

The third well, which is a leased property, is on the west side of Humberstone village and is known as the Hopkins well. Its capacity is 500,000 feet per day.

Every street and alley-way of Port Colborne have been piped by the company, making about seven miles of service pipes, and the number of consumers in the village is about 200. It also supplies the Ontario Silver Co's. works at Humberstone.

The rates are $1 per month for cooking stoves, $1.50 for heaters, 18c. per month for ordinary tips, 25c. for medium, and 50c. for large lamps.

ONTARIO SILVER PLATING CO.

The Ontario Silver Plating Co. began business at Thorold ten years ago, but in December, 1890, the plant was removed to Humberstone, the inducement being an offer by the Mutual Gas Co. to furnish free gas for fuel for a term of ten years.

A 75 h. p. boiler supplies steam to drive the machinery and heat the building, and gas is the only fuel used for generating the steam. Gas is also used for annealing, and the estimated daily consumption is 50,000 cubic feet in winter and 25,000 to 30,000 in summer. This is equivalent to two tons of soft coal per day.

THE WAINFLEET DISTRICT.

In 1869 Mr. John Reeb purchased 20 acres of lot 6 in the first concession of Wainfleet, on the line of the Grand Trunk Railway three miles west of Port Colborne, and began to manufacture lime.

Until February, 1890, the fuel used at these works consisted of a mixture of coal and wood, which cost about $4,000 a year.

In November, 1889, Mr. Reeb began to bore on the property for gas, and the well was finished in February of the following year at a depth of 854 feet. Sulphur gas was found at 456 feet which yielded enough to run one kiln, and pockets of gas were struck all the way down to the white Medina sandstone at 823 feet. The greatest flow was obtained at 685 feet, in Clinton limestone.

The capacity of the well has not been measured, but it is sufficient to furnish fuel for two kilns with a producing capacity of 720 bushels of lime per day, and for three boilers which drive a hoisting engine, drills, pump, etc., besides light and fuel for six dwelling houses; and the well pressure with all fires running is 230 lb.

With wood and coal fuel 75 bushels of lime per kiln were drawn three times in the day of 24 hours, whereas with gas fuel 90 bushels per kiln are drawn four times in the day. The daily production has therefore been increased by 270 bushels, and this advantage is secured at an expenditure of $1,900 for drilling, casing and completing the well.

But in computing the economy effected with the use of gas fuel account has also to be taken of the labor of handling wood and coal, which is now dispensed with; so that while the efficiency of the works has been increased by 80,000 bushels a year the cost of labor and fuel has been reduced by not less than $4,500.

As an offset to this economy however there is the increased duty on lime under the McKinley tariff, for almost all the lime produced at these kilns is shipped to Buffalo. Before that tariff went into operation the duty on a carload of lime was $4; now it is $15.

Following is the record of this well as furnished by the contractor, Mr. S. E. Humphrey:

	Thickness.	Depth.
Drift feet	2	2
Corniferous limestone	16	18
Lower Helderberg limestone, fair cement rock	5	23
" " cement rock and shale	7	30
Impure limestone with shale and gypsum (Onondaga)	390	420
Niagara limestone	185	605
Niagara shale	79	684
Clinton limestone and shale	30	714
Mottled Medina stone	46	760
Shaly Medina sandstone	40	800
White Medina sandstone	23	823
Medina shale	31	854

Gas was obtained at 430, 448 and 466 feet and salt water at 468 feet, in Niagara limestone; but the principal flow the contractor says was got in the Clinton limestone at 685 feet, and from the white Medina sandstone at 800 to 815 feet. The well was cased to 632 feet, in the Niagara shale.

THE PROVINCIAL NATURAL GAS AND FUEL COMPANY.

The largest operations in the Haldimand and Welland field are being carried on by the Provincial Natural Gas and Fuel Company of Ontario. This company was organised in May, 1889, with a capital of $500,000, which has since been increased to $600,000, the leading mover in the enterprise being Mr. Eugene Coste of Amherstburg, formerly connected with the Geological Survey. Mr. Coste began to explore the county of Welland as soon as the company was organised, for which purpose leases were procured on a large number of farms in territory supposed to be gas-bearing.* He had the benefit of the

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* The following lease is copied from a file in the Registry office of the county of Welland, and is one of the regular forms saving as to details of terms and conditions:

Memorandum of agreement and lease made and entered into this 17th day of September, A.D. 1891, by and between Edward T. Green, of the county of Welland, in the province of Ontario of the first part, and the Provincial Natural Gas and Fuel Company of Ontario (Limited) of the second part.

Witnesseth, That the party of the first part in consideration of one dollar in hand paid, the receipt of which is hereby acknowledged, and the covenants, rents and stipulations hereinafter contained, has granted, demised and let unto the said party of the second part the exclusive right of drilling and operating for petroleum, oil and gas, and taking and removing same therefrom upon all that certain tract of land situate in the township of Humberstone, county of Welland, province of Ontario, and bounded and described as follows: [Description of lot 6 in 5th concession, 87 acres.]

The party of the second part to have and to hold the right hereby granted peaceably and quietly for the said purposes only on the following conditions:

If petroleum oil be obtained or produced, the said party of the second part hereby agrees to give the party of the first part one-tenth part of all the oil obtained on the said premises or the cash value of same at the option of the party of the first part.

If gas be found the said party of the second part further agrees to give the party of the first part $100 per annum for each 3,000,000 feet of gas per day found on said land as long as said gas well may be utilised by the party of the second part, and the privilege of using free of charge enough gas in one house on the premises for ordinary household purposes.

It is further agreed that if after one year from the date of this agreement a well has not been drilled on the premises, the party of the second part to retain the right hereby granted will pay to the party of the first part a rental of $21.50 per annum until work is commenced.

The party of the first part grants to the party of the second part the right of using sufficient water for all necessary purposes from the premises hereby leased except from wells used by the party of the first part, the right of way through said premises, the exclusive right to lay pipes to convey oil and gas, and the right to bring upon said premises and erect or remove any machinery or fixtures required by the party of the second part: Provided that no well shall be drilled within 200 feet of a house or barn or in orchard experience of those parties who had bored at Port Colborne and its vicinity, and selected as the location of the company's first well lot 35 in the third concession of Bertie, about seven miles east of Port Colborne. The territory since explored by borings has an area of twenty-eight square miles, being four miles in breadth from north to south and seven miles in length from east to west. No. 1 well is midway between the north and south and a little east of the centre of the east and west limits. Its record as given by Mr. Coste is as follows :

		Thickness.	Depth.
Soil and Drift	feet	3	3
Corniferous limestone		77	80
Onondaga limestone and shale, with gypsum		345	425
Guelph and Niagara limestone		225	650
Niagara black shales		55	705
Clinton limestone, white and gray		30	735
Medina sandstone and shale		115	850

For 80 feet in the Medina formation the drill passed through red, followed by 15 or 20 feet of dark shale. Below this came 15 or 20 feet of white sandstone, in which at a depth of 846 feet the gas was struck.

In other wells deeper borings have been made into the Medina shale, but no gas has been found in it. In some wells gas has been found in the Clinton formation, but in all of them the greatest flow proceeds from the Medina sandstone.

Drilling operations were carried on by the company steadily in 1889, and five wells were finished before the end of that year. In 1890 the work continued, and by the first of October, 1891, eighteen wells had been drilled and six others were in progress. Three of the completed wells have however been abandoned, although a small quantity of gas was found in each of them.

In one locality a show of petroleum has been found in the Medina sandstone, the following account of which has been given to me by Mr. Eugene Coste under date of 30th December, 1891 :

> In answer to your enquiry of December the 24th I would say that the report is correct about the discovery of petroleum in one of our wells north and west of Sherkston, on lot 10 in the third concession of Humberstone. This is our well No. 20, which we completed on the 24th of October last. The oil was struck in it at the depth of 770 feet, in the Medina sandstone. It is a beautiful light oil of 44 Beaumé ; its color is light green and amber, like the best Pennsylvania oils, and there is no sulphur in it, the smell being quite sweet. We have since struck another oil well (our No. 28) 1,500 feet west and north from the first, on lot 11 of the same concession. The quality of the oil from this second well is just the same as from the first.

Fresh water in large quantity is found in all the wells from a few feet in the rock to about 335 feet, but the depth varies a little in each well. A very strong magnesian salt water is met with at 550 feet, but by sinking a $5\frac{5}{8}$-inch casing to 600 feet the water is shut off. In some wells the Drift consists of 50 or 60 feet of clay, which is bored, and an 8 inch drive pipe is put down to the rock. The dip of the formations, as shown by the records of the wells, is found to be uniformly about 30 feet per mile to the south.

Small quantities of the gas yielded by the wells of this company are supplied to consumers in the locality, and at the village of Victoria on the Niagara river, but the great bulk of it is delivered through pipe lines to the Buffalo Natural Gas Fuel Co. This company was organised in 1886, and it has a pipe line 90 miles long from the Bethlehem

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without the consent of the party of the first part, and that all pipes will be laid under ground at a sufficient depth unless a special consent is obtained from the party of the first part, and so as not to interfere with cultivation.

In the event of any damage done to the crop or other produce on the land hereby demised by the party of the second part, it is further agreed that the party of the first part shall be compensated therefor at the rate of $25 per acre for each acre of crop or other produce so destroyed.

Failure on the part of the party of the second part to comply with the conditions or to pay the cash considerations herein mentioned, either to the party of the first part in person or to his credit at the Imperial Bank at Port Colborne, will render this lease null and void and not binding on either party.

It is further agreed between the parties to this agreement that all conditions between the parties hereto *shall extend to* their heirs, administrators, executors and assigns.

In witness whereof the said parties have hereunto set their hands and seals the day and year first above *written.*

field in Pennsylvania to the city of Buffalo. But owing to low pressure in that district, which has gradually been falling, the company turned its attention to the Ontario field, and a contract was made with the Provincial Natural Gas and Fuel Co. under which pipe connection was made with Buffalo in January, 1891, and now this is the chief source of that city's supply of natural gas. The Buffalo company charges consumers 25 cents per 1,000 cubic feet as indicated by house meters; and under the contract terms the Provincial Co. receives 50 per cent. of the rates, which has enabled it to pay one quarterly dividend of 6 per cent. on its capital stock of $600,000—and a portion of its capital is water.

An 8-inch delivery pipe has been laid down from the side-road between lots 8 and 9 of Humberstone along the road allowance between the first and second concessions to a point near the townline between Humberstone and Bertie. Thence it has been laid north-east in Bertie to the Bowen road, and east along that road to the Niagara river. Branch lines of 2 to 6 inch pipes collect the gas from the several wells of the company to the main pipe. These pipes are wrought iron of tested strength, and large sizes are laid a foot under ground; but pipes of 2 to 3 inches diameter are laid on the surface when alongside fences or elsewhere out of the way, as the flow of gas is affected only in a slight degree by conditions of heat or cold.

Drip tanks are placed near each well to receive sand or moisture which may be forced up; but the gas contains no tar or other foreign material, and if there are no leaks the gas flows freely in all kinds of weather.

The rock pressure varies in the wells, ranging from 500 to 550 lb., while the yield ranges from 300,000 to 12,500,000 cubic feet per day of 24 hours. The average of fifteen wells supplying the main pipe line is 2,500,000 cubic feet per day as measured in the open air, but it must be much less at the point of consumption, owing to the effect of friction. At Victoria the gas is delivered to consumers under a pressure of 4 to 5 oz.

The expansion of natural gas under pressure produces intense cold, and experiments made at Victoria station by S. P. Stiker of Buffalo showed that mercury was reduced to 40° below zero C. With an alcohol thermometer the temperature was reduced to 80° below zero F.

CARROLL BROS. LIMEKILNS AND GAS WELLS.

Carroll Bros. of Buffalo have been carrying on operations on the lake shore in Humberstone for six years, burning lime and quarrying limestone and sand for the Buffalo market. The dunes which rise here to the height of fifty feet above the lake, and which extend for many miles along the north shore of the lake west from the Niagara river, furnish an inexhaustible supply of sand of excellent quality for building and road-making purposes. In the construction of asphalt and stone pavements large quantities are used in Buffalo, the bulk of which is furnished by the Carroll Bros. So that operations might be carried on at all seasons a 1¼-mile railway was built four years ago from the Grand Trunk station at Sherkston to the lake shore, passing alongside the limekilns, and additional tracks have been laid down at the foot of the dunes along the beach for a distance of 2½ miles. Extensive docks have also been built where vessels may be loaded with sand, lime and limestone during the season of navigation. About forty cords of limestone are shipped per day to Buffalo, where it is used in chemical works and for flux at the iron furnaces. The firm employs seventy-five men at their several works in the summer months, and their average for the year is fifty.

The limekilns and quarries are on lot 4 in the first concession of Humberstone, and have been worked for many years. When Carroll Bros. acquired the property they erected a new kiln with a capacity of 75 barrels (10 tons) per day. To produce this quantity of lime required a consumption of eight cords of wood, at a cost of $2 per cord.

In March, 1890, a well was bored near the kiln for gas, which yielded about 2,000,000 cubic feet per day. The firm had no assurance of striking gas here, as the first well bored by them was a failure, although located within a hundred yards of one sunk by the Provincial Co. which yielded 5,000,000 feet per day. But their second well only repeated for them the experience of many others, and while a large volume was wasted at first—

the well having been given free vent for six or seven days at a time—the pressure is still 500 lb. as against 560 lb. when first opened.

Four other producing wells have been drilled on this property, and in August of 1891 the firm united with the Erie County Gas Co. of Buffalo for further development of the territory and the supply of gas to that city. Three additional wells have been put down since, two of which are productive, and a pipe line has been laid down to convey gas to Buffalo.

Carroll Bros. have also erected a second limekiln with a capacity of 125 barrels per day, which has been in operation since the beginning of September. The gas used for fuel is reduced to a pressure of 3 oz. through two regulators, and is mixed with air in the furnace. With this cheap fuel they are enabled to sell lime in the Buffalo market at 80 cents per barrel, although the duty has been increased under the new tariff from 4 to 15 cents per barrel.

BERTIE NATURAL GAS COMPANY.

The Bertie Natural Gas Company was organised February 21, 1891, with a capital of $2,000, afterwards increased to $8,000, and with headquarters at the village of Ridgeway, on the Buffalo and Goderich line of the Grand Trunk Railway. B. M. Disher is president, H. N. Hibbard managing director, and A. H. Kilman secretary-treasurer. A contract to drill for gas on a lot selected in the village was let in March to Carmody Bros. Work was commenced April 15, and the well was finished June 8. Following is the record of boring:

	Thickness.	Depth.
Flinty limestone	feet 60	60
Shale and gypsum	90	150
Hard shale	5	155
Shaly rock	30	185
Slate and gypsum	15	200
Slate and shale	230	430
Limestone	115	545
Silicious limestone, salt water	15	560
Hard limestone	110	670
Slate	50	720
Clinton limestone	10	730
Shale	10	740
Red Medina sandstone	70	810
Sandstone, salt water	5	815
Light colored sandstone	5	820
Dark shale	20	840
White Medina sandstone	12	852
Red shale	18	870

Water was struck at 100 feet, and was met with at intervals to 250 feet, and it was shut off with a $5\frac{5}{8}$-inch casing at a depth of 660 feet. A bed of rock salt it is said was met with near the bottom of the boring.

The first gas was found in Clinton limestone at 725 feet; the second in red Medina sandstone at 785 feet; but the best flow was obtained at the level of 840 to 850 feet in the white Medina. A 3-inch pipe has been put down to the bottom of the well, through which the gas from the second and third horizons is delivered to the service pipe. The gas from the Clinton limestone is delivered separately through the casing pipe.

Gas was supplied to cottages at Crystal Beach, east of Point Abino, during the summer, and on the 27th September it began to be supplied to village consumers, the number of applicants being sixty, and the rate $25 a year for a cooking stove, heater and two jets. The receipts of the company to the end of the year were $479.57.

The rock pressure is estimated at 500 lb., but it is reduced by two Fulton & Chapman regulators to 5 oz. at the consuming point.

NIAGARA FALLS GAS FUEL AND LIGHT CO.

The Niagara Falls Natural Gas Fuel and Light Co. was organised under an Ontario charter in the spring of 1889 with an authorised capital of $30,000, whereof $8,000 was subscribed. A well was bored the same year on the farm of Mr. L. McLashan, on the west side of Drummondville, to a depth of 1,080 feet. A small quantity of sulphur gas was found at a depth of 202 feet and boring was discontinued in red shale.

A second well was drilled on J. G. Cadham's farm, three-quarters of a mile south of the village, to a depth of 1,260 or 1,280 feet. Gas was got in white Medina sandstone at 300 feet, but the bed was only two feet in thickness and the yield was light. The well was cased off at that depth, but nothing was found below it—not even water.

In the spring of 1891 the operations of the company were renewed in the township of Humberstone, it having been financially strengthened in the meantime and the stock increased to $50,000. Leases were obtained on 500 acres in the southern part of the township.

The first well was drilled on the Barass farm in the first concession, just west of Carroll Bros.' limekilns. Its total depth is 917 feet, and gas was found in a bed of sandstone 21 feet thick at a depth of 860 feet. The yield of gas was not measured, but it was estimated to be 1,000,000 cubic feet per day; the rock pressure was 590 lb.

The company's second well is on David Michell's farm east of Sherkston, on the first concession of Humberstone, and was finished on the 3rd of October. The gas was found in the sandstone here also, and it is claimed that the capacity is 5,000,000 to 6,000,000 cubic feet per day.

THE WELLAND DISTRICT.

In 1891 two companies were formed to prospect for gas in the vicinity of the town of Welland, the first with $2,000 and the second with $3,000 capital. Two wells were bored during the summer and fall by the Carmody Bros. and the results in both cases were nearly the same.

The first well was located on Alexander Asher's farm, a quarter of a mile southeast of the village, and was let under contract to drill to a depth of 800 feet. The following record has been furnished by the drillers:

	Thickness.	Depth.
Drift	feet 113	113
Soft slate	107	220
Hard limestone	210	430
Slate or shale	50	480
Clinton limestone	20	500
Red Medina sandstone	52	552
Slate or shale	25	577
White Medina sandstone	20	597
Red shale	115	712

Eighty-five feet of the Drift consisted of clay and quicksand. Water was met with at the surface of the rock and again at a depth of 300 feet, and was cased off at the bottom of the hard limestone (430 feet). A light flow of gas was struck in the red Medina sandstone at 512 feet, which continued without apparent abatement.

The second well is on the farm of Mr. Leitch, half a mile south of the first, and half a mile northeast of the Welland station of the Canada Southern Railway. Here the rock was struck at 112 feet, the Drift being composed of clay, quicksand and gravel. Following is the record of boring:

	Thickness.	Depth.
Drift	feet 112	112
Slate or shale	118	230
Limestone	240	470
Slate or shale	50	520
Clinton limestone	13	533
Red Medina sandstone	45	578
Slate or shale	25	603
White Medina sandstone	20	623
Red shale	82	705

In this well about four times as much gas was found as in the other, but it was in the Clinton formation and continued only two days, when it diminished almost to the vanishing point.

The contract for the first well was let at $1.70 per foot and for the second at $1.50, the company furnishing for the latter the drive and casing pipe; the same persons were for the most part shareholders in both companies.

THE DUNNVILLE DISTRICT.

In April of last year a company was organised at Dunnville to bore for natural gas, known as the Dunnville Natural Gas Company, with F. J. Ramsay as president, L. A. Congdon secretary and John Taylor treasurer. At first the capital was $5,000, but after the discovery of gas it was increased to $20,000.

A contract to bore a well was let to Carmody Bros. to a depth of 800 feet, at $1.65 per foot, the contractors to furnish casing and drive pipe, and work was begun on the 22nd of June. The place selected is at the eastern end of the village, on the north side of the Welland canal feeder. Here the Drift was found to be 76 feet deep, 4 feet of the surface being yellow loam and 72 feet below it blue clay. The log of the well is as follows:

	Thickness.	Depth.
Drift	feet 76	76
Brown limestone and thin layers of gypsum	74	150
Hard shale, with gypsum	205	355
Hard Niagara limestone	210	565
Soft shale or slate	47	612
Clinton limestone	24	636
Slate or shale	4	640
Red Medina sandstone	45	685
Hard shale or slate	40	725
White Medina sandstone and shale	15	740
White Medina sandstone	12	752
Red shale	20	772

Sulphur water was struck at 85 feet, and weak brine at 500 feet. The well was cased to the bottom of the Niagara limestone at 565 feet.

The first show of gas was found in the Clinton formation at 612 feet, and this bed yields about one-fifth of the total flow. The second show was obtained in the white Medina sandstone between 740 and 752 feet, but the strongest flow came from 747 feet. The boring was continued into the red shale below this bed so that it might serve as a drain or pocket to receive any fragment of sand or other rock which might fall into it.

The well was finished on the 22nd of August, when the gas showed a pressure of 335 lb., and the yield was estimated at 150,000 to 200,000 cubic feet per day, measured with an open flow.

A second well was commenced immediately after the first was finished, on the left bank of the Grand river and distant about a mile from the first, which was bored to a depth of 780 feet. Following is the record:

	Thickness.	Depth.
Drift	feet 70	70
Limestone	80	150
Shale and slate	190	340
Hard limestone	227	567
Shale or slate	45	612
Clinton limestone	22	634
Shale or slate	1	635
Red Medina sandstone	45	680
Slate and shale	50	730
White Medina sandstone	20	750
Reddish shale	30	780

A third well put down by the same company gave the same record as the second, and the average flow of each of the three wells is 150,000 cubic feet per day. The maximum pressure is 335 lb., but during supply it falls to 200 lb. The daily consumption is about 100,000 cubic feet.

The second and third wells were shot with 30 quarts of nitro-glycerine each, which had the effect of doubling their flow of gas.

THE CAYUGA DISTRICT.

In the fall of 1891 steps were taken to explore the country in the vicinity of Cayuga for gas, and on the 25th of November Carmody Bros. began to bore a well on the lef bank of the Grand river, within the village bounds. On the 16th of January of the present year the boring was finished in the Medina shale at a depth of 710 feet, with the following record :

	Thickness.	Depth.
Drift, clay	feet 23	23
Limestone	120	143
Shale	132	275
Hard limestone	232	507
Slate or shale	41	548
Clinton limestone	15	563
Slate or shale	5	568
Red Medina sandstone	35	603
Shale	62	665
White Medina sandstone	15	680
Red shale	30	710

The well was cased to a depth of 508 feet with $5\frac{5}{8}$-inch casing, and gas was foun at three levels, viz.: in the Clinton limestone, in the red Medina and in the white Medin sandstones. The daily yield is estimated to be 210,000 cubic feet.

THE NEW TORONTO FIELD.

Perhaps the most important fact connected with the discovery of natural gas in New Toronto is, that natural gas has been discovered there at all. But in the opinion of th best authorities on the subject gas in greater or less quantity may be found in all th sedimentary rocks, so that there is no certainty of its being obtained in paying quantit in every field where its existence has been proved. On the other hand, there is possibility of its being found in great abundance ; but there is only one way o determining the matter, and that consists in making a full and possibly a costly exploration of the ground by deep borings.

THE ASYLUM WELL.

New Toronto is one of those speculative suburbs of Toronto which have recentl been called into being by real estate men, and is situated in the township of Etobicok on the western side of the village of Mimico. The new cottages for the insane, know as the Mimico asylum, are on the lake shore west of Mimico, and here in 1889 a dee well was bored with the object of procuring a supply of water for the institution. Th depth of this well is 1,061 feet, and near the bottom of it a vein of bitter water wa struck which rose in the bore 350 feet No fresh water was found, and the boring wa therefore discontinued. But small flows of gas were met with which encouraged the hop that a supply of this valuable mineral might be procured which could be utilised to giv the institution light and fuel. Inspector Christie thereupon sought expert opinion o the matter, and first consulted Dr. Bell of the Geological Survey, who replied as follow under date of August 20, 1889 :

> You probably struck the Utica formation at 575 feet and passed quite through it in th next 150 feet. The gas you got at 725 feet would indicate that you had then entered th Trenton formation, which is somewhat jointed and open and allows the passage of ga through it, while the Utica probably would not.
>
> At 1.000 feet you would likely be 275 feet into the Trenton, and at 1,061 feet 336 feet or more than half way through that formation.
>
> I don't think your chances of a strong gas well would be much improved by borin deeper, although there is always a possibility of finding more gas till you are quite throug the Trenton, as a comparatively thin layer of impervious shale or clay under great pressur is sufficient to hold down gas. We do not know the exact thickness of the Trenton grou (including the Black River and Birdseye) under Toronto, but it may amount to 500 or 550 feet
>
> Before sinking any deeper I think it would be well to try the effect of a dynamit cartridge.

Mr. Christie next consulted Mr. Eugene Coste, manager of the Provincial Natura Gas and Fuel Company, who examined the well and made the following report upon i under date of September 14, 1889 :

In accordance with the desire expressed in your letters of the 31st August and 5th o this month re the deep well sunk by the Government at the Mimico cottages in which natural gas was struck, I examined the well on the 11th inst., and after a careful consideration of the matter I now beg to report as follows:

The flow of natural gas struck at the Mimico cottages well, though burning with a nice little flame, is very small and has no commercial value even though it is so near the cottages.

Indeed even when made to flow from one-inch pipe it does not give any measurable flowing pressure on a water gauge, thus indicating a quantity of gas equal only to two or three thousand cubic feet a day of 24 hours.

This, I understand from the record kept of the boring, was struck at three different depths, viz.: 425, 575 and 1,052 feet, indicating of course the flow of each vein to be smaller again.

It may be said with certainty that no good vein of gas was encountered in the descent, though there is no doubt from the depths given above that the gas was struck in the Trenton limestone, below the Hudson River and Utica black shales, which were the first strata traversed in boring.

From the fact of the gas being found at Mimico in the Trenton limestone, the great famous reservoir of oil and gas in Ohio and Indiana, most geologists would conclude that the chances for augmenting the flow by the firing of a torpedo or for obtaining large quantities in other wells sunk in the neighborhood are good; but in my opinion this is not the case, and I have no hesitation in saying that it would be entirely useless (though it could be done without the least danger to the cottages) to shoot the well, or to sink it deeper, or to sink other wells near by in the hope of getting large quantities of gas.

Notwithstanding the generally admitted idea among geologists, the fossiliferous matter of the Trenton limestone (either animal or vegetable) has nothing to do with the production of natural gas, no more than the organic matter of any other strata.

In my opinion natural gas and petroleum have been originated by an entirely different action than the decomposition of organic remains.

This action only took place in certain districts, and according to my studies on the subject it did not take place at Mimico or around Mimico.

My conclusion is, then, that it is entirely useless to look there for more than what little escape was found, which escape may come from districts miles and miles away.

'No accurate record of the boring was preserved, saving that the total depth was 1,061 feet, that salt or bitter water was found near the bottom which rose in the bore to a height of 350 feet, and that small flows of gas were supposed to have been met with at 550. 725 and 1,000 feet; but there is no certainty on these latter depths. However the discovery of gas in a second well in the vicinity in the early months of this year suggested to the Inspector the propriety of shooting the well with cartridges of nitro-glycerine. This was done, but without resulting in any apparent increase of the flow.

The formation at Mimico is Hudson River shale, which has a probable thickness of 700 feet, and there is little doubt that the boring entered the Trenton limestone.

THE SYNDICATE WELL.

The syndicate of real estate men who founded the town of New Toronto were induced by a knowledge of the showing at the asylum well to test their own property, being impressed by the great possibilities of natural gas as a factor in promoting a new town. Accordingly steps were taken late in 1891 to put down a deep well, and experienced drillers were brought over from Pennsylvania to undertake the work.

The boring penetrated the Hudson River shales and all the underlying formations to the Laurentian rocks, to a depth of 1,312 feet, when it was concluded that the quest was hopeless. A moderate flow of gas was found, according to the report of one of the drillers, at 780, 885 and 1,089 feet, with signs of oil at the second level. At 1,250 to 1,260 feet bitter water was struck which rose 600 feet in the well.

After the boring ceased the well was plugged at 1,200 feet, and it was shot at three different levels, with the result of increasing the flow of gas quite perceptibly. The capacity has not been measured, but it is understood that the pressure as indicated by a steam gauge was only 45 pounds.

Here as at the asylum well there is some doubt of the depths at which gas was found, and it is not absolutely certain that it had more than one source.

No samples of the borings were kept, but samples of rock thrown out by the lowest shot leave no doubt that they came from the Trenton limestone.

The syndicate proposes to sink one or more wells in the locality, feeling confident that a good supply of gas may be found there in spite of the views of some of the scientific experts whose opinions have been obtained.

THE MANITOULIN FIELD.

It has already been stated that the Cincinnati arch is believed to extend northward across the island of Manitoulin, and it is well known that petroleum exists in the Trenton limestone there. It also appears that natural gas has been struck in several wells, and the following memorandum on the subject has been given to me by Mr. F. A. Fenton of this city, who spent some time in exploring La Cloche island and other districts near Manitoulin for minerals last year.

GAS AT LITTLE CURRENT.

In the fall of 1890, about 1½ miles from the town of Little Current, a well was sunk on the farm of Robert Morphet, which at a depth of 120 feet yielded and still yields a steady flow of gas. A well was also drilled on the property of Mr. John Lynch at Little Current, in which there was a small showing of gas. During the summer of 1891 another well was put down on a farm about 4 miles southwest of the town to a depth of about 260 feet, at which depth drilling ceased because of the pressure of gas. It was with great difficulty that the last mentioned hole was plugged and at the present time a large amount of gas escapes daily, so much indeed that it is dangerous to light a match within 25 or 30 feet of the hole. As in Ohio, the gas and oil bearing rock of Manitoulin island is in the Trenton limestone, which there underlies the Clinton and Niagara limestones and Utica shales.

I am informed by Dr. Bell that none of the wells referred to by Mr. Fenton are likely to be good producers, as they have been bored in the valleys or synclinals. If natural gas exists in large quantity in that locality Dr. B. thinks it will be found near one or other of the arches or uplifts which cross the island along north and south lines.

ON THE ORIGIN, OCCURRENCE AND VALUE OF NATURAL GAS.

Our experience of natural gas in Ontario is confined to two localities, and does not date farther back than three years. Accordingly we cannot pretend to know much about it from our own observation, and if we would avoid mistakes which may cost us dear the reasonable course to pursue is to aim at being guided by the experience and observation of others. It has therefore occurred to me that in treating of the origin, occurrence and value of natural gas I could not do better than present the views of the best authorities in the gas and petroleum regions of the United States, in the hope that persons in our own country who are interested in the search for and production of natural gas, as well as all who may be interested in the uses to which it is applied, may be guided into the best course alike for producers, consumers and the whole community. It will be observed that on some scientific aspects there are sharply defined lines of dissagreement between scientific men, especially on the occurrence of gas and petroleum. But upon the utilitarian side there is no division of opinion; every one recognizes the economic value of natural gas, and the folly of wasting it.

ORIGIN OF NATURAL GAS.

Various theories have been put forward by scientific men to account for the mode of origin of petroleum and natural gas, all of which have been stated and considered by Prof. Peckham in the tenth volume of the census of the United States, 1880, and discussed by other authorities since. Those theories may be divided into two classes, viz: (1) the chemical theory, which refers the origin of bitumens to an inorganic source—a result of chemical affinity upon mineral matter; and (2) the geological theory, which regards bitumens as the result of a decomposition of animal or vegetable substances

which have been stored in the rocks. The extracts which follow present for the most part the latter theory, which is generally entertained by American geologists.*

Petroleum and natural gas, which for the moment play so distinguished a *role* in the history of the Pittsburgh region, are merely supplemental to its prosperity—a temporary, a fugitive condition to its wealth; and, although inseparable from the main features of the carboniferous geology, yet to be treated entirely apart from coal in our forecast of the future. They make indeed a most important chapter in our description of the geology of the region; but that chapter will be seen in course of time to be merely an appendix to the book. They go together into the chapter; for oil and gas are but two aspects of one and the same substance, originally united and still in combination; the one a product of the other: but neither of them holding any natural relationship to coal. The oil and gas obtained from cannel coal and the coal shales are not the same as the oil and gas which spouts and roars from the bore-holes. The cannel coal and coal shales are themselves of a different nature from embedded bituminous coal, having been produced in a different way originally, and having a different internal constitution.

Moreover, although the Dunkard creek oil and gas come from one of the rocks of the coal measures, the oil and gas product of western Pennsylvania at large comes from a great formation underlying all our coal measures, one in which no coal bed has ever been seen: and therefore, even if the oil and gas of that subcarboniferous formation were not generated in the formation itself, and have ascended from a greater depth, they are still further removed from any relation to the coal measures.†

As is known, the wells which in Ohio have been sunk to the vicinity of the Huron shale have very generally yielded oil, but only in small quantity. The difference in the productiveness of this oil horizon in Ohio and Pennsylvania has caused considerable surprise and disappointment. It seems to me however easy of explanation. On Oil creek the strata which underlie the surface are: First, the argillaceous shales of the Waverly group and Upper Chemung, which form the sides and bottom of the valley; below these, several beds of sandstone, interstratified with shale which belong to the Upper Chemung and Lower Portage groups; still lower, the black shales of the Portage and Genesee having a thickness of several hundred feet. These strata have all felt the disturbing influence of the forces which raised the Alleghany mountains. Here then we have a peculiar geological substructure, such as is specially favorable to the production and accumulation of petroleum, and such as must be more or less perfectly paralleled elsewhere to make productive, or at least flowing wells possible. . . .

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* The principal advocates of the chemical theory are Berthelot, a French chemist, and Dr. Mendeleeff of St. Petersburg. The views of the latter are shown in the following extract from a paper read by Mr. William Anderson before the British Association in 1889, published in Science, vol. XIV p. 230:

"It is generally admitted that the crust of the earth is very thin in comparison with the diameter of the latter, and that this crust encloses soft or fluid substances, among which the carbides of iron and of other metals find a place. When in consequence of cooling or some other cause a fissure takes place through which a mountain range is protruded, the crust of the earth is bent, and at the foot of the hills fissures are formed; or, at any rate, the continuity of the rocky layers is disturbed and they are rendered more or less porous, so that surface waters are able to make their way deep into the bowels of the earth, and to reach occasionally the heated deposits of metallic carbides, which may exist either in a separated condition or blended with other matter. Under such circumstances it is easy to see what must take place. Iron, or whatever other metal may be present, forms an oxide with the oxygen of the water. Hydrogen is either set free or combined with the carbon which was associated with the metal, and becomes a volatile substance; that is, naphtha. The water which had penetrated down to the incandescent mass was changed into steam, a portion of which found its way through the porous substances with which the fissures were filled, and carried with it the vapors of the newly formed hydrocarbons, and this mixture of vapors was condensed wholly or in part as soon as it reached the cooler strata. The chemical composition of the hydrocarbons produced will depend upon the conditions of temperature and pressure under which they are formed. It is obvious that these may vary between very wide limits; and hence it is that mineral oils, mineral pitch, ozokerite and similar products differ so greatly from each other in the relative proportions of hydrogen and carbon. I may mention that artificial petroleum has been frequently prepared by a process analogous to that described above.

"Such is the theory of the distinguished philosopher, who has framed it not alone upon his wide chemical knowledge, but also upon the practical experience derived from visiting officially the principal oil-producing districts of Europe and America, from discussing the subject with able men deeply interested in the oil industry, and from collecting all the available literature on the subject. It is needless to remark that Dr. Mendeleeff's views are not shared by every competent authority; nevertheless the remarkable permanence of oil wells, the apparently inexhaustible evolution of hydrocarbon gases in certain regions, almost forces one to believe that the hydrocarbon products must be forming as fast as they are consumed, that there is little danger of the demand ever exceeding the supply, and that there is every prospect of oil being found in almost every portion of the surface of the earth, especially in the vicinity of great geological disturbances. Improved methods of boring wells will enable greater depths to be reached; and it should be remembered that apart from the cost of sinking a deep well there is no extra expense in working at great depths, because the oil generally rises to the surface or near it. The extraordinary pressures, amounting to three hundred pounds per square inch, which have been measured in some wells, seem to me to yield conclusive evidence of the impermeability of the strata from under which the oil has been forced up, and tend to confirm the view that it must have been formed in regions far below any which could have contained organic remains.

† J. P. Lesley, State Geologist of Pennsylvania, in Transactions of the American Institute of Mining Engineers, vol. XIV. p. 620.

The influences that control the escape of carburetted hydrogen from the bituminous strata seem to be the same as those which regulate the flow of petroleum. The origin of the two hydrocarbons is the same, and they are evolved simultaneously by the spontaneous distillation of carbonaceous rocks. The source of the petroleum and the abundant flow of gas with which it is associated on Oil creek, the gas and less abundant petroleum of Erie and other points on the lake shore, is undoubtedly the Huron shale; and we must look to the physical condition of this and the associated strata for an explanation of the great variation in productiveness which they exhibit in different localities. . . . Where the oil and gas producing rocks and those overlying them are solid and compact, decomposition of the organic matter they contain takes place very slowly, and the escape of the resulting hydrocarbons is almost impossible. Where they are more or less shaken up decomposition takes place more rapidly; reservoirs are opened to receive the oil and gas, and fissures are produced which serve for their escape to the surface. Near the Alleghanies all the rocky strata are more or less disturbed, and here along certain lines the liquid and gaseous hydrocarbons are evolved in enormous quantities. As we come westward however we find the rocks more undisturbed, and the escape of oil and gas through natural or artificial orifices gradually diminished.*

1. In the first place, all forms of bitumen must be considered together. They constitute a definite and well graded series throughout. There is no question, for example, as to mineral tar being derived from petroleum. Mineral tar *is* partially oxidized petroleum, and it is obvious therefore that this element needs no separate theory as to its origin.

In like manner no line can be drawn between mineral tar and asphalt. Asphalt is simply petroleum still further oxidized, and we are therefore absolved from the necessity of providing a theory for the origin of asphalt in addition to the origin of petroleum.

When petroleum so called is considered a great many varieties of crude oil are found to be included under the term, depending partly upon the chances for oxidation that the products have had. Natural oils range in gravity from below 20 degrees to above 50 degrees, Beaumé, the former so thick that they can scarcely be poured, the latter light enough to be burned in common lamps in the crude state.

If a line were to be drawn anywhere in the series it would be between gas and oil. The former as we know originates under many conditions in which petroleum does not appear, but on the other side petroleum is never found free from inflammable gas, and in a large way all the facts and the occurrences of both so exactly correspond that it is impossible to separate them in respect to their origin.

Which of these is the original substance? The question has been already answered. Petroleum is the parent product. From it all the varieties of the series are directly derived. Our task then is a simple one to this extent We are to inquire how rock oil originates in nature. When we can answer this question, we know that we understand as well how mineral tar and asphalt, and natural gas also, originated.

2. In the second place we need to bear in mind that the various members of the bituminous series are abundantly and almost universally distributed among the unaltered sedimentary rocks of the earth's crust. The valuable accumulations of these substances are rare, it is true, but one can scarcely go amiss of petroleum, asphalt or gas, at least in small quantities, among the stratified rocks that retain their original structure. In particular, the rocks of the entire Ohio valley can be said to be charged with petroleum. A well cannot be drilled at any point in the valley for even a few hundred feet in which careful examination will not reveal the presence of some representative of this bituminous series. The aggregate of this disseminated petroleum is often found to be very large. A fifth of one per cent. of petroleum, if distributed through a thousand feet of rock, would make a total to the acre or square mile far beyond any production that has ever been realized from the richest oil field, and percentages of this amount are not only not rare to find, but are even hard to miss.

It is a popular impression that oil and gas are unusual substances in nature. The object of this paragraph is to show that this impression is entirely unfounded, and that we must free our minds from it if we would consider in proper light the questions as to the origin of rock oil.†

In the same report from which the foregoing extract is quoted Prof. Orton sums up the two main views on the origin of petroleum held by American geologists as follows:

1. Petroleum is produced by the primary decomposition of organic matter, and mainly

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* T. S. Newberry in Geology of Ohio, vol. I. pp. 160 and 192.

† Prof. Edward Orton in the Geological Survey of Kentucky, 1891, pp. 29-30.

in the rocks that contained the organic matter. Of this view Hunt is one of the chief advocates.*

2. Petroleum results from the distillation of organic hydrocarbons contained in the rocks, and has generally been transferred to strata higher than those in which it was formed. Newberry and Peckham have been quoted at length in support of this general theory. Newberry holds that a slow and constant distillation is in progress at low temperatures. Peckham refers the distillation of the petroleum of the great American fields to the heat connected with the elevation and metomorphism of the Appalachian mountain system.†

And in his general summing up on the subject Prof. Orton puts the various views of geologists in the form of the following propositions:

1. Petroleum is derived from organic matter.
2. Petroleum of the Pennsylvania type is derived from the organic matter of bituminous shales, and is probably of vegetable origin.
3. Petroleum of the Canada type is derived from limestones, and is probably of animal origin.
4. Petroleum has been produced at normal rock temperatures (in American fields) and is not a product of destructive distillation of bituminous shales.
5. The stock of petroleum in the rocks is already practically complete.‡

I have been favored by Mr. W. J. McGee of the Geological Survey of the United States with advance sheets of a report he has prepared for the Survey in which the subject of Rock Gas and Related Bitumens is very ably dealt with. To Mr. McGee's mind the hypotheses suggested by observations in Indiana, by the phenomena of the bitumen fields of the world, by common manufacturing processes, by the results of laboratory experimentation, and by observations upon a well known natural process, are as follows:

1. Rock gas is a simple product of slow primary decomposition at low temperature of organic matter (animal and vegetal) contained in natural sediments.
2. Petroleum is a simple product of primary decomposition of organic tissues imbedded in sediments when the process is long continued or accelerated by rise of temperature, increase of pressure, or orogenic movement.
3. The heavier bitumens may be products of primary decompositioh of organic matter contained in sedimentary strata when the process of decomposition is exceedingly long continued or greatly intensified by heat, pressure or structural deformation; but some of them are doubtless residual, left after evaporation of the lighter members of the series.
4. In recent deposits gas alone may be generated, but in older deposits gas and oil are commonly generated simultaneously in proportions varying with the rate of the process and the extent to which it has been carried; or in brief,
5. Rock gas, petroleum and the heavier bitumens are simple products of natural processes of decomposition of the organic matter contained in sediments; and their weight and other attributes depend upon the conditions under which decomposition takes place.

A popular impression exists that the gas is being continually produced, but this is not a fact in a commercial sense as far as the natural gas deposits of the Appalachian region are concerned. Natural gas and petroleum are intimately associated with one another. In all gas reservoirs it is possible to find petroleum, sometimes however in such infinitesimal quantities that it is of no commercial value, and can only be found by a very careful examination of the gas-producing rock. Natural gas is also always to be found in the rocks which produce petroleum, although in the latter case the amount is so small as not to be practically valuable.§

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[*] In writing of the oil fields of Canada in the American Journal of Science Dr. Sterry Hunt said: "The facts observed in this locality appear to show that the petroleum, or the substance which has given rise to it, was deposited in the bed in which it is now found at the formation of the rock. We may suppose in these oil-bearing beds an accumulation of organic matters whose decomposition in the midst of a calcareous deposit has resulted in their complete transformation into petroleum, which has found a lodgment in the cavities of the shells and corals immediately near. Its absence from the unfilled cells of corals in the adjacent and interstratified beds forbids the idea of the introduction of the oil into these strata either by distillation or by infiltration. The same observations apply to the Trenton limestone, and if it shall be hereafter shown that the source of petroleum (as distinguished from asphalt) in other regions is to be found in the same fossiliferous limestones, a step will have been made toward a knowledge of the chemical conditions necessary to its formation."

† Ib. p. 42. ‡ *Ib.* p. 60. § Charles A. Ashburner in Trans. Am. Inst. M. E., vol. xviii. p. 291.

In the same paper (p. 290), Mr. Ashburner says:

By gas in commercial quantities I mean gas in such quantity that, if utilized wi proper care and economy, it would generate steam at a cost below the cost at which t same duty could be obtained from the use of coal or wood at current prices, and that t net revenue from the use of the gas would be such as to give a reasonable profit on t capital invested in the drilling of the well and the piping of the gas to the consumer, a at the same time provide for a sinking fund to replace this invested capital within the ti when it might be considered that the gas-producing rock would become absolutely e hausted. It is important in this connection to bear in mind that natural gas, like all oth mineral deposits, can be exhausted. In a commercial sense a gas-reservoir is not unlik coal-bed. For every cubic foot of gas taken out of a gas-reservoir there is just one cu foot less remaining.

The close and invariable proximity of limestone to the wells has been noticed by writers, but they have been most impressed by its being "fossiliferous" or shell limesto and have drawn the erroneous inference that the animal matter once contained in th shells originated petroleum, but no fish oil ever contained *paraffin*. On the other hand t fossil shells are carbonate of lime, and as such capable of producing petroleum und circumstances such as many limestone beds have been subjected to. All limestone roc were formed under water and are mainly composed of calcareous shells, corals encrinit and foraminifera, the latter similar to the foraminifera of "Atlantic ooze" and of Engli chalk beds. Everywhere under the microscope its organic origin is conspicuous. Lim stone is the most widely diffused of all rocks, and contains 12 per cent. of carbon. Petroleu consists largely of carbon, and there is a far larger accummulation of carbon in the lim stone rocks of the United Kingdom than in all the Coal measures the world contai A range of limestone 100 miles in length by 10 miles in width and 1,000 yards in dep would contain 743,000 million tons of carbon, or sufficient to provide carbon for 875,0 million tons of petroleum. Deposits of bituminous shale have also limestone close at han *e.g.* coral-rag underlies the Kimmeridge clay, which is more or less saturated througho with petroleum, and it also underlies the famous black shale in Kentucky which is extr ordinarily rich in oil.*

Occurrence of Natural Gas.

Among American geologists there is little difference as to the manner in whi natural gas occurs. Their testimony is that gas is found invariably in a porous or fissured rock; in sandstone of more or less open composition; in pebbly beds whi formed shore lines in the ancient seas; in limestone which has become porous by co version into dolomite; or in limestone of a cavernous character or which is broken wi jointings; and that the gas is confined within its reservoir by an impervious cover shale or other rock. But as to whether it occurs in arched rocks invariably, either anticlines or monoclines, or in synclines and level beds as well as in the others, there a very pronounced differences of opinion; as also on the causes which produce gas pressu The views of the two opposing schools are presented in the following extracts:

It is difficult to prescribe any fixed limits in the geological scale to the occurrence natural gas and petroleum. Every known rock, except the eruptive rocks, contains t remains of organic matter, animal and vegetable; and since it is quite certain that bo oil and gas result from the decomposition of organic remains, it is quite possible to fi oil and gas in rocks of any geological age, subsequent to the Archæan or rocks witho life: in some rocks in commercial quantities, and in other rocks in quantities so small to be only of scientific interest to the geologist and mineralogist.

Next to the necessity of having a sedimentary bed, such as sandstone, shale or sla in which animal or vegetable remains of past geological ages have been buried, or a lin stone bed made from water shells, the presence of natural gas is dependent upon the e istence of a porous or cavernous rock to serve as a reservoir to hold the gas, and of overlying impervious rock-roof to confine the gas. The other necessary conditions for t occurrence of gas are more dependent upon the forces to which the strata have been su jected and the resulting geological structure than upon the age of the rocks themselves.†

Mr. J. P. Lesley, state geologist of Pennsylvania, has given the following sh statement of principles involved in the answer to the question so often asked, Shall bore for gas at my works?

1. There can be no gas stored up in the oldest rocks.

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[*] The Origin of Petroleum by O. C. D. Ross, Report of the British Association for 1891, p. 640.

[†] C. A. Ashburner in Trans. Am. Inst. M. E., vol. xv. p. 507.

2. There can be no gas left underground where the old rocks have been turned up on edge and overturned, fractured and recemented, faulted and disturbed in a thousand ways. If there ever was any, it has long since found innumerable ways of escape into the atmosphere.

3. Where the rock formations lie pretty flat and have remained nearly undisturbed over extensive areas, there is always a chance of finding gas (if not oil) at some depth beneath the surface.

4. Wherever rock oil has been found, there and in the surrounding region rock gas is sure to exist.*

Two conditions dominate the gas production of the Trenton limestone of Indiana as of Ohio; one chemical in its origin and nature, and one physical. The first condition is concerned with the porosity of the rock and the consequent possibility of storage of gas, oil and salt water in it, the latter state being probably essential to all vigorous production of either oil or gas. The second condition is concerned with the relief of the surface of the gas rock, and upon this also Nature inexorably insists in all gas and oil production. . . . The gas rock of Indiana as well as that of Ohio is a true and tolerably pure dolomite or magnesian limestone in the only cases in which chemical examination of it has been made. . . The analysis of the Trenton limestone outside the limits of production are equally valuable and significant. They show at a glance the cause of the barrenness of the rock southward. The stratum there becomes unproductive because it loses its porosity, or, to put the facts in a more natural order, the stratum becomes productive only when the dolomotic change has been accomplished in it. The mass of the Trenton limestone throughout the country at large, ninety-nine hundredths of it probably is a non-porous rock. . That the Trenton limestone must be a porous rock to be an oil or gas rock goes without saying. As just shown, the highest degree of porosity in it is associated with a dolomitic composition, but its porosity ensures only the result that the rock shall be filled with one of three substances, gas, oil or salt water, almost invariably associated in all petroleum fields. Which of the three will be found occupying any particular portion of the porous part of the rock depends altogether on the relations of this particular portion to adjacent parts of the same stratum in the matter of elevation: in other words, on the local relief of the stratum. In every field in which oil or the gas derived from it is accumulated, certain comparatively small portions of the porous rock, always distinguished from the rest by relatively higher elevation, will be found assigned as it were to the storage of these desired substances, while the salt water holds possession of the bulk of the stratum on all sides.†

Referring again to the condition of "relief" or "uplift" in the rock, Prof. Orton explains that it

Results from some slight warping of these ancient strata in the course of their history, whereby the common contents of the porous portions of the Trenton limestone have been differentiated by gravity, the gas and oil seeking the highest levels and the salt water maintaining a lower but definite elevation in every field. The salt water level is necessarily the dead line of oil and gas production in the several sub-divisions of the productive territory. . . .

The influence of the remarkable discovery of oil and gas in the new horizon of Ohio and Indiana has been felt far and wide. Drilling directed specifically to the Trenton limestone has been undertaken on the strength of this discovery in many states and in localities 1,000 miles distant from the regions in which it was first found profitable. . . It is sufficient to say that there is nothing in the new experience to make it safe to count the Trenton limestone an oil rock or a gas rock in any locality unless it can be shown to have undergone the *dolomitic replacement* by which its porosity is assured. Even in case it has undergone this transformation it will not be found a reservoir of oil or gas in an important sense unless, in the accidents of its history, some parts of its deeply-buried surface have acquired the *relief* that is essential to a due separation of its liquid and gaseous contents. It is not known, nor has it been rendered even probable, that the limestone meets these two inexorable conditions anywhere in its wide extent except in regions that are now undergoing development, as the gas fields and oil fields of Ohio and Indiana. In other words, there is a strong presumption that the Trenton limestone will not prove an oil rock or a gas rock in any new field.‡

The general conditions upon which the occurrence of natural gas seems to depend, from a consideration of the facts at present at our command are: (*a*) the porosity and homogeneousness of the sandstone which serves as a reservoir to hold the gas; (*b*) the extent to which the strata above or below the gas-sand are cracked; (*c*) the dip of the gas-sand and the position of the anticlines and synclines; (*d*) the relative proportion of water, oil and gas contained in the gas-sand ; and (*e*) the pressure under which the gas exists before being tapped by wells. Other conditions may still be discovered which will have as important a bearing upon the problem as those which I have stated. . . .

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*Annual Report of the Geological Survey of Pennsylvania for 1885, pp. 679-80.

†Prof. Edward Orton in the report of the U. S. Geological Survey for 1886-87, pp. 641-2-3. ‡*Ib.* pp. 653-62.

It would appear that the gas is closely related to petroleum, and that their origin is due largely to the same cause—the decomposition of animal and vegetable life. It is believed that the gas is not indigenous to the sand-rock from which it is obtained, but comes from the decomposition of life-forms which were entrapped in underlying strata. If this be so the amount of gas contained in any one sand depends first upon the extent to which the rocks are cracked between the horizons of such organic remains and the gas-sand reservoir in order to permit the gas to flow into the sand; and second upon the extent to which the rocks are cracked above the gas-sand which would permit the gas to escape into the atmosphere and totally disappear. . . .

The first necessary condition for the presence of gas however is dependent upon the existence of a porous rock to serve as a reservoir to hold it. A number of wells have been drilled which have found gas, but, if the drillers' records are to be credited, have not pierced sand-beds ; in these cases the gas has been unquestionably obtained from a crack in the strata which serves as a conduit to convey the gas from its sand-bed reservoir to the well. Although the dip of the gas-sand and position of the anticlines and synclines have an important bearing upon the occurrence of gas (in many cases this would seem to be the most important consideration), yet it is not believed that natural gas wells can be located on what has been formulated as the 'anticlinal theory,' since all great gas wells are not found along anticlinal axes, although some of the largest and most important wells in Pennsylvania have been found in such positions. A great many wells have been drilled in synclines which have found gas. These two statements are of great importance, since a large amount of money is now being expended in drilling wells which have been located on the basis of the anticlinal theory, so-called. . . .

The relative proportion of water, oil and gas in a sand-bed, and the pressure under which the gas exists have an important hearing upon its occurrence, when considered in conjunction with the dip of the sand and the position of anticlines. If nothing but gas existed in a given homongeneous sand-bed having only the ordinary dip of the strata in the oil region from which the gas could not escape by cracks into overlying strata, and the quantity of confined gas being such that it should fill all portions of the rock with gas under a great pressure, it must be apparent that, no matter where the gas-sand was pierced by a well, the same quantity of gas would be obtained excepting so far as it might be influenced by the force of gravity. If petroleum, water and gas should all exist in the same sand-bed the pressure on each would necessarily be approximately the same if there was an open connection throughout the whole extent of the rock in which they occurred ; but the water would seek the lowest level of the sand-bed, the oil the next, and the gas would be found in the highest portions. The same condition of affairs would exist where either water or oil existed in the sand with the gas to the exclusion of the other.

A careful study of these facts makes it apparent that under special conditions the anticlinal theory alone may account for the existence of gas ; but when however it is known that large gas wells have been found in synclines under conditions differing from those which obtain in the vicinity of gas wells on anticlines, it is quite certain that the occurrence of natural gas in Pennsylvania and New York regions cannot be explained but by a careful consideration of all the geological and physical conditions under which it is procured.

The facts relating to the geology of natural gas now in the possession of any one geologist are not sufficiently numerous or connected to permit the acceptance of any ultimate theory ; and it is only possible for the present to deduce special geotectonic conditions under which natural gas has so far been exploited. Some of these conditions are so varying and apparently antagonistic that it is only possible to arrive at any general law controlling the occurrence of natural gas by a comparison of the individual facts obtained from innumerable well-drillings.*

THE ANTICLINAL THEORY.

The anticlinal theory that gas wells should always be located on anticlinals and not on synclinals, because gas is lighter than water or oil and should seek the highest reservoirs—premises a permeable sand rock containing water, oil and gas, or only water and gas, in such proportions and under such conditions that the fluids may stratify themselves as freely and completely as they would do in an open tank under air, the water and oil at the lower levels and gas at the higher.

There is nothing new in the theory, as many suppose, for it has been long ago discussed and illustrated in text-books on geology and in nearly every book published relating to the production of petroleum. Well-locators however gave it but little attention until developments intended exclusively for natural gas commenced.

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* C. A. Ashburner in Trans. Am. Inst. M. E. vol. XIV. pp. 430-33-34-37-38.

Wherever the proper conditions exist there seems to be no objection to accepting an anticlinal as one of the factors in locating gas wells; but in most cases it is being too inconsiderately used without giving due thought to other and much more important considerations.

First, it is proven by the experiences of over 25 years that no profitable oil or gas well can be obtained in the Upper Devonian strata and rocks of later ages in the Pennsylvania oil fields unless a good sand-rock reservoir is found. Second, it is a generally accepted conclusion that the oil and gas making material was deposited before—and perhaps in some cases with—the producing sand-rock, not after it; that the tendency of gas and oil when generated is upward not downward. Therefore the two primary conditions to be sought are gas-producing materials and sand-rock reservoirs to hold the products. All others are secondary, for without these no profitable oil or gas wells can be had.

Now what has an anticlinal to do with these indispensable qualifications? Evidently nothing in a primary sense, for it had no existence when they were being prepared. Nevertheless I have heard experienced operators self-confident in their geological acquirements, assert that certain oil fields could not extend beyond fixed limits on account of anticlinals which interrupted the deposition of the oil sands when they were forming.

It is well known that all our oil rocks are sedimentary; that they are composed of materials derived from older rocks, the disintegrated particles of which have been sifted, assorted and deposited in stratified layers by the action of water. These rocks are known to be several thousand feet in thickness, and untold ages elapsed while they were forming. For the purposes of this discussion we need go no further back in the eons of the past than the time when the Murraysville gas-sand (taking a definite stratum to avoid confusion) was completed by those changes of conditions (whatever they were) which terminated the sand deposits at that spot and commenced to lay down the overlying shales. At that date the two most important requisites for a future gas field had been provided. The gas making material had been deposited; the receiving tank, so to speak, put in place and the impervious cover was being put on. But the sedimentary deposits were not yet completed. Other carbonaceous shales, other sandrocks, alternating with beds of coal, slates, fireclays and limestones were yet to be superimposed to a height of 3,000 feet or more. These all were deposited in the course of time in regularly stratified layers, showing that no deep-seated unequal or local disturbance had occurred up to the date of their completion. Subsequently some great change took place. The whole region was lifted above ocean level, the Alleghany mountains rose in crested ridges, and the Murraysville anticlinal with other comparatively minor flexures was formed. Now what effect could these anticlinal movements have had upon the gas producing capabilities of the rocks at Murraysville, whereas we have seen the gas materials and the reservoirs had been provided ages before? Had the hydrocarbons stored in the shales lain dormant all these ages, awaiting some awakening energy to set them free, which could only be furnished by the crush and pressure accompanying anticlinal movements? This can hardly be admitted, for oil and gas are plentifully found in regions where the rocks have not been so affected. Did the anticlinal movement open up crevices below the gas-sand leading down to some deep-seated storehouse of gas beneath the sedimentary rocks? This question is open to the same objection as the former one; and furthermore is it not reasonable to suppose that the side thrust and pressure which caused these anticlinals to rise would have a tendency to consolidate the basal shales confined under a heavy mass of incumbent strata, and to fracture and loosen the rocks near the surface if anywhere? Is it probable that gas after forcing its way up through thousands of feet of clay-shales and slates, such as have been penetrated by wells to the depth of at least 1,800 feet without encountering any noticeable leads, would stop in the gas-sand only checked by a covering of a few feet of clay-shale overlaid mostly by sand-stone to the surface?

If then anticlinals had no part in depositing the gas making materials, and sand-bed reservoirs were not the special agents that caused the generation of gas to commence and did not open crevices to deep-seated sources of unlimited supplies, what other favorable conditions could they have been instrumental in originating to make them more prolific in gas now than any other locality? I can imagine but one, which is this: When the anticlinal uplift tilted and warped the previously horizontal strata, destroying the equilibrium of the fluids in them a new adjustment of their positions in the sand-beds followed. This readjustment, in cases where all the conditions were favorable, probably resulted in storing larger quantities of gas in the anticlinals than elsewhere; but we have no assurance that all the arches were thus fortunately circumstanced, or that the conditions making one part of an arch productive would be equally efficient in another part.

The drill has demonstrated that the permeable sand rocks lie in beds so inclosed in impervious shales that each bed practically forms a reservoir itself. In certain horizons these sand beds are numerous and persistent, as for instance in the Venango-Butler group. But each individual bed has its *locus* and its characteristic fluids. In the same well one may produce water, another oil, another gas, another a mixture of all three, and only a few feet of shale intervene between the different layers of sandstone. All these rocks were equally affected by the general uplift and now lie dipping to the southwest at an average rate of from 18 to 22 feet per mile.

If the sand rocks were continuous instead of being in chains of beds or pools, and sufficiently porous to allow fluids to circulate through long distances,—say, for instance, from the southerly part of the Butler oil belt at Herman station to Murraysville—then according to the principles upon which the anticlinal theory is founded the Murraysville rock should now be deluged by water while the Herman station rock should be stored with gas, for the monoclinal slope of 22'± to the mile would submerge the anticlinal at Murraysville where the gas sand on the crown of the arch is more than 200 feet lower than it is at Herman station.

In applying the anticlinal theory to locating gas wells, this great monoclinal slope has in most cases been lost sight of by those who do not understand the geological structure of the country. Knowing the tendency of gas to seek the higher levels, and only stopping to learn that an anticlinal is an arch in the rocks, they procure a geological report, trace out the anticlinal referred to, secure leases upon it, as they suppose, and drill wells. If no gas is obtained, the Survey is charged with not having located the anticlinals correctly. They overlook the fact that the crests of anticlinals slope with the progressive dips of all the rocks towards the southwest, and that this has an important bearing upon the question of anticlinal reservoirs. For example, the Brady's Bend arch is 450'± lower at the Ohio river than it is at Lardintown, Butler county; the Murraysville axis is 250± lower where it crosses the Pennsylvania railroad than at Murraysville. Now if the whole county between Lardintown and the Ohio is underlaid by a permeable sandstone containing water and gas, and which produces gas at Lardintown on the crown of the arch and water on its flanks (in the synclinal) say 225 feet below its crest, then if the fluids are free to seek natural levels water would cross the anticlinal's crest half way between Lardintown and the Ohio (for there the crest has fallen 225 feet, which puts it on a level with the watered synclinal at Lardintown), and going southwesterly from that point the anticlinal must be as thoroughly water-logged as the synclinals. Hence this universally prevailing monoclinal dip is quite as important a factor in locating gas wells as the anticlinals are; for while the former affects the whole country, the latter only favorably affect local areas.

This persistent southwesterly dip has been referred to time and again in our geological reports. From the oil fields of New York to the gas fields of Pittsburgh it may be noticed that the southwesterly ends of productive pools frequently contain more water than the higher slopes. The Brady's Bend axis has been found full of water up to a certain point going northeast; so has the Murraysville; so has the Bull creek or Tarentun. In fact if the anticlinal theory is worth anything this phase of it requires to be specially studied. As before stated the productive sand rocks of the oil regions are generally deposited in elongated beds, stretching out in a northeast and southwest direction. One of these containing water and gas might lie between two anticlinals scarcely affected by either; in which case, according to the anticlinal theory, the elevated northeastern end should be good gas territory, although it might lie exactly in a syncline. Another bed might trend down from the unwarped regions at the north and have its southerly end uplifted by an anticlinal. Say it is ten miles long—nine miles on the monoclinal slope carries it down about 200 feet and if it rises 100 feet in the next mile to the crown of the anticlinal it is there level with a point in the same stratum four and a half miles from its northerly end; and should the sand bed contain a little more water than gas, or its southerly end have less storage capacity than its northerly end, the sand on the anticlinal would be as completely water-logged as in the synclinal north of it. Carrying the illustration still farther, if a sand rock at a higher or lower geological level commences under this anticlinal and extends southwardly, it should be gas-bearing not only on the anticlinal but also in the syncline towards the south, unless it has but little length or is uplifted by another anticlinal a short distance south.

The effects produced by an anticlinal are further modified no doubt by the partial or complete porosity of the sand beds, the relative proportions and qualities of the fluids contained in them, and the different degrees of pressure under which they are confined.

These may be called fanciful suppositions, but they are neither impossible nor improbable, and knowing that such heterogeneous physical conditions may exist we should be warned that no theory based on *one idea*, however plausible it may appear, is worthy of acceptance. Yet locators with such theories are most in popular favor, even with many who very well knew (if they will but pause to consider) that no man in any age, whatever his pretensions may have been, ever discovered an infallible rule for unerringly locating ore beds or oil and gas wells. And we may confidently add that the diversified conditions under which all minerals exist make it absolutely certain that no such rule ever will be discovered. The oil regions are strewn with financial wrecks caused by an overweaning confidence in one-idea theories delusively formulated upon accidental successes and often having no foundation whatever in fact.*

Within the last few years, since natural gas has attained such prominence in Pittsburgh, its sources and the conditions of its occurrence have been studied anew with sharpened inspection by both geologists and practical men, and some real advance seems to have been made in our search for it. The anticlinal theory has been revived and extended, and has been used successfully in the location of many productive wells. For the new statement we are indebted to Professor I. C. White of the University of West Virginia, and recently of the Pennsylvania Geological Survey. Professor White in turn gives credit to Mr. W. A. Earsenian, an oil operator of many years' experience, who had noticed in 1882-8 "That the principal gas wells then known in western Pennsylvania were situated close to where the anticlinal axes were drawn on the geological maps. From this he inferred there must be some connection between the gas wells and the anticlines." Professor White goes on to say:

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*John F. Carll in Geological Survey Report of Pennsylvania, 1885, pp. 45-51.

"After visiting all the great gas wells that had been struck in western Pennsylvania and West Virginia, and carefully examining the geological surroundings of each, I found that every one of them was situated either directly on or near the crown of an anticlinal axis, while wells that had been bored in the synclines on either side furnished little or no gas, but in many cases large quantities of salt water. Further observation showed that the gas wells were confined to a narrow belt, only one-fourth to one mile wide, along the crests of the anticlinal folds. These facts seemed to connect gas territory unmistakably with the disturbance in the rocks caused by their upheaval into arches, but the crucial test was yet to be made in the actual location of good gas territory on this theory. During the last two years I have submitted it to all manner of tests, both in locating and condemning gas territory, and the general result has been to confirm the anticlinal theory beyond a reasonable doubt.

"But while we can state with confidence that all great gas wells are found on the anticlinal axes, the converse of this is not true, viz., that great gas wells may be found on all anticlinals. In a theory of this kind the limitations become quite as important as, or even more so than, the theory itself; and hence, I have given considerable thought to this side of the question, having formulated them into three or four general rules, (which include practically all the limitations known to me up to the present time that should be placed on the statement that large gas wells may be obtained on anticlinal folds) as follows:

"(*a*) The arch in the rocks must be one of considerable magnitude. (*b*) A coarse or porous sandstone of considerable thickness, or, if a fine-grained rock, one that would have extensive fissures, and thus in either case rendered capable of acting as a reservoir for the gas must underlie the surface at a depth of several hundred feet (five hundred to two thousand five hundred feet). (*c*) Probably very few or none of the grand arches along mountain ranges will be found holding gas in large quantity, since in such cases the disturbance of the stratification has been so profound that all the natural gas generated in the past would long ago have escaped into the air through fissures that traverse all the beds. Another limitation might possibly be added, which would confine the area where great gas flows may be obtained to those underlaid by a considerable thickness of bituminous shale.

"Very fair gas wells may also be obtained for a considerable distance down the slope from the crest of the anticlinals provided the dip be sufficiently rapid, and especially if it be irregular or interrupted with slight crumples. And even in regions where there are no well marked anticlinalls, if the dip be somewhat rapid and irregular, rather large gas wells may occasionally be found if all other conditions are favorable."*

To the qualifications already made Professor White would probably add, at this time, one to the effect that gas wells shall be located on the domes of the axis rather than its depressions, recognizing the same line of facts in regard to them that Minshall had already established in the case of the White Oak anticlinal of Ohio and West Virginia, to which reference has previously been made.

The facts cited by Professor White as to the gas supply of Pittsburgh are conclusive. Every foot of it comes from anticlines, but not from them because it has been sought nowhere else, but because, if found in other stations it is speedily overcome and extinguished by salt water. Where anticlines of the type here referred to traverse an oil-bearing series it may be considered demonstrated that they exert a decided effect on the accumulations of oil and gas in this series. So rational is such a conclusion, so directly does it result from the facts already stated, that it is hard to see on what grounds it can be called in question.†

The whole community interested in the subject of natural gas has been carried away by a theory. Practical men and theorists have apparently changed sides; the so-called theorists maintaining a conservative attitude; the so-called practical men becoming wild theorists. And the theory to which I allude is the anticlinal theory of gas.

Stated in a few words, it is a theory that oil, being lighter than water, must rise to higher levels. If the application of this theory was confined to bottles no one would dispute it; the water in a bottle must collect at the bottom, the oil in the middle, and th gas on top. But the earth is not a bottle, It has no great caverns in it. More than that, the arrangement takes place naturally under the pressure of only one atmosphere; while any arrangement of water, gas and oil made at depths of a thousand or two thousand feet must be made under pressures of from 100 to 400 pounds to the square inch.

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* Science, vol. v. p. 522. † Prof. Orton in the Geological Survey of Kentucky, 1891, pp. 78-80.

Mr. Carll recites a case where gas escapes at a pressure of 450 pounds to the square inch. It is impossible therefore that any arrangement of water, oil and gas can occur in the deep oil rocks such as occurs in a bottle. If the anticlinals at Pittsburgh were like those in middle Pennsylvania, where the rocks instead of lying nearly flat are turned up nearly vertical, the water, oil and gas at great depths, if they could exist at all, would remain practically mixed like the carbonic acid gas in a soda water fountain. It therefore seems to me irrational to assign any importance whatever to the extremely gentle anticlinals of the gas-oil region. To this I add the important consideration that the movements of oil and water have been shown by actual practice to be governed entirely by the character of the rock in which they take place, and that they are effectually stopped at fixed geographical lines where porous rock changes into sandstones and sandstones into shales. And these changes of character in the rock itself have no fixed relation whatever to the anticlinal waves, which on the contrary cross them transversely or diagonally.

Finally, sufficient instances can be adduced to refute the popular assertion that great gas wells are struck only on anticlinal lines; for some of them deliver gas from the bottom of basins. And on the other hand holes sunk on well known anticlinal lines, and not far from good gas wells, have yielded little or no gas at all.*

THE THEORY OF HYDROSTATIC PRESSURE.

The question of how far the hydraulic head may account for the gas well pressure (on purely artesian principles) deserves and is receiving attention. But those who especially favor this theory must not ignore, as they are probably well aware, the *unknown factors in the problem*, viz: the distances and methods of connection with the surface; the rate at which the water-flow, and consequently the water-pressure, is transmitted down hill from the outcrop head to the well bottom in the deep; the stoppages of the water-way here and there by tight rock; the interposition of mud cracks across the water-way, etc. To get the observed pressure at Pittsburgh, for example, one must go for a high-head outcrop as far north as Venango county; but the porous oil rocks do not extend continuously that far; nor is any water-bearing stratum known to be continuous a sufficient distance to answer the requirements. Nor can a nearer local head be assumed with any confidence, because the water-flow in that case must be vertical.

Friction in a pipe line is estimated to reduce gas pressure at the rate of about 7 lb. per mile. In doing this it reduces the theoretical rate of velocity with which gas would deliver from the free mouth of any section of a pipe.†

It is generally understood that the strongest rock pressures obtain in the deepest wells; and the theory of *hydrostatic pressure* has been appealed to to account for the fact. No one however has yet been able to work out from actual observations of the phenomena presented by flowing oil and gas wells any absolute and uniform correspondence between increasing pressures and increasing depths, as compared with the immediately overlying surface, or with distant elevated outcrops of the producing strata.

If an oil well is simply an artesian well, should not its flow be constant while it lasts, and dependent upon the rapidity with which the impelling water invades the oil rock reservoir; and after displacing the oil ought not water to follow into the well and rise to the surface, or at least to the level indicated by the strength of its initial oil flow?

But oil and gas wells do not act in this way. The output decreases gradually and sometimes rapidly from the start; and after production has settled almost to its minimum the wells may be pumped for years and even subjected to the drafts of gas pumps without being flooded with water, provided the abandoned wells in the pool have been effectively plugged above the oil and gas rock.

It is a well known fact that the oil sand in the celebrated Triumph district, which has been under the drill and pump for over 22 years, and produced on the aggregate fully 5,000-000 barrels of oil accompanied by large volumes of gas, is now so voided by the use of gas pumps that a vacuum gauge at any of the well heads registers a downward pressure of 12 to 13 lb. per square inch. This has been the situation for many years, as gas pumps have constantly been in operation in that district since 1869. New wells are occasionally drilled in this exhausted belt, and it invariably happens that when the oil sand is pierced a current of air commences to whistle down the hole, nor can any oil be obtained till the well mouth is closed and a gas pump put in operation. After a few days testing oil begins to appear and the production frequently runs up to 15 to 20 barrels per day. Then, as the slight excess of fluid in the immediate vicinity of the well drains and an equilibrium is established, the output gradually shrinks to the level of the old wells in the pool.

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* J. P. Lesley in Trans. Am. Inst. M. E. vol. xiv. pp. 654-5.

† J. P. Lesley in Annual Report of the Geological Survey of Pennsylvania for 1885, p. 664. Elsewhere in the same report he says, "Evidently the gas must in some way produce its own pressure; like gas generated by chemical reaction in a closed vessel." p. 661.

The wells at Triumph are from 600 to 800 feet deep, and usually have only from 200 to 250 feet of casing in them, consequently some four or five hundred of the bore hole is bare rock, equally exposed to the draft of the pump as the oil rock itself. In this uncased portion of the well are the first and second sands, which also outcrop in the river hills within two miles of the exhausted pool; and one member of the second sand forms a part of the river bed a mile farther north, and yet no surface water or air finds access to the wells through these sources.

Many other proofs of the impermeability of the strata above the oil rocks and of the fallacy of the hydrostatic theory could be adduced were it necessary. In a practical experience of twenty-three years in the oil regions I have never witnessed nor heard of a single circumstance to support it. The theory as applied to Pennsylvania oil and gas wells is delusive and untenable, and the cause of the great rock pressure witnessed must therefore be sought for in some other direction. [*]

The cause of the rock pressure of gas and oil wells is a subject upon which our best authorities have not been in haste to commit themselves by offering definite and comprehensive theories to account for the facts. Three causes have been suggested as adequate to explain the results:

1. The gas produces its own pressure. Solid or liquid matters in the rocks are there converted into the gaseous form, and the gas thus formed repuires larger space than the solid bodies from which it was derived. In seeking this larger space it exerts the pressure noted.
2. The weight of the overlying rock produces the pressure of the gas. According to this view the gas is in the rock and the weight of the earth above it exerts a constant pressure upon it, and forces it out with the velocity observed whenever an exit is made for it.
3. The pressure is due to a water column that is behind the gas and oil. The porous stratum that makes the reservoir of gas and oil and salt water, and which always has an impervious roof, somewhere rises to the surface. Water entering at its outcrops will exert its pressure through all the flexures of the stratum upon the salt water that it contains, and thus upon the accumulations of oil or gas that are held within the arches and terraces of the stratum. This explanation makes the flow of gas and oil depend upon precisely the same cause that occasions the flow of water from artesian wells, viz: a water head of greater or less elevation, at a greater or less remove.[†]

Commenting on these theories Mr. Orton believes that the first has some element of truth, and for the pressure of shale gas he can see no other cause. But he argues that the facts in regard to the great gas and oil rocks require a cause more energetic and more variable than the expansive power of gas could furnish, for if gas originates its own pressure it would be difficult to account for the extreme range of pressure that we find in the same stratum, all the gas of which has essentially the same composition.

As to the second theory, Mr. Orton is of opinion that Mr. Lesley has demonstrated its invalidity by showing that the rock can exert no pressure on the gas unless its particles are free to move upon one another. This implies that the rock is in a crushed state, but no force can be found adequate to crush the rock at the depths at which the gas occurs. The driller finds it intact, and samples of Trenton limestone procured after a well is shot are seen to be full of pores in which the gas finds storage.

The third theory finds a more ready acceptance, since all observation shows that in oil fields the driller finds gas in the higher levels of productive rock, at a lower level he finds the stocks of oil (if any) with which the reservoir is charged, and at a still lower level he reaches salt water that sometimes fills the well entirely. "Every oil or gas field has a margin of salt water surrounding its productive portion, in whole or in part. The influx of this salt water is one of the most common evidences of total failure in wells drilled for oil or gas. The moment this fatal flood is reached all hope departs." The gas it may be is confined to narrow streaks on the crests of anticlines and occupies a few feet at most in the upper portion of the rock, while the salt water stretches out for scores of miles on every side and through great depths in the rock. "We have no reason to believe that all the accumulations of petroleum contained in the crust of the globe would exceed a few cubic miles in volume, but the salt water contained there would make a sea."

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[*] John F. Carll in Geological Survey of Pennsylvania, 1890, vol. I 5, pp. 12-13.

[†] Prof. Edward Orton in the report of the United States Geological Survey for 1886-87 p. 594.

When an opening is made in the rock the gas, oil and salt water rise as water rises in an artesian well, and the height to which the gas rock rises at its nearest outcrop will determine the height to which the salt water will rise in the well. This is the factor which controls the so-called "rock" pressure of the gas, but obviously it is "water" pressure instead. The "rock pressure" phrase came in with the second theory. Mr. Orton draws the following inferences from the acceptance of the hydrostatic theory:

1. The definite limitation of all supplies of gas and oil stored in rock reservoirs is emphasized by this view of the origin of rock pressure. If salt water is the moving force all speculations of a constantly renewed supply of either gas or oil are vain and idle.
2. Other things being equal, the pressure will be greatest in the deepest wells.
3. The rock pressure of gas may perhaps be continued with little abatement of force until the end of the production of a field is near. The maintenance of pressure is no proof whatever of a maintenance of supply. The last thousand feet of gas come out from the gas holder with as much force as the first thousand feet.
4. In a field that combines both oil and gas, but in which the reservoirs of these substances are differentiated, the first sign of approaching failure will be the invasion of either level by the contents of the division next below it.*

The third of these inferences may require some modification, in view of the observed fact that pressure in all gas districts is found to diminish gradually after one or more wells have been flowing steadily for some time. For when the gas in reservoirs is released by the drill it is not only forced to the surface by the pressure of water behind it but by its own elasticity also; and as the water cannot occupy the space left by the gas as fast as the latter escapes, having to flow through rock of less or greater density as well as to overcome the dilating energy of the gas which remains in the reservoir, the pressure must of necessity be gradually reduced.

PRESENCE OF SALT WATER IN OIL AND GAS ROCKS.

Oil rocks and gas rocks have been shown to be porous rocks, covered with impervious shales, and in some way connected with underlying sources of petroleum. Are there any porous strata that are entirely and exclusively devoted to the storage of these fossil hydrocarbons? None such are known. All the gas rocks and oil rocks that have ever been worked have, without exception, contained in some part of their extent water, and in the great majority of instances salt water. When the rock lies at comparatively small depth, as for example less than 500 feet, it often contains fresh water, but generally at greater depths and sometimes at less as well, it is for the most part occupied with salt water in all portions of it that are not filled with oil and gas. Even when occupied with fresh water at shallow depths the same stratum when followed to a greater depth generally becomes a salt-water rock. This association of salt water and oil has been conspicuous from the first. It will be remembered that the original discovery of oil and gas in deep wells came from drilling that was undertaken in the search for salt water. It is certainly true that all the strata which have yielded brine for salt manufacture have, in some portion of their extent, yielded gas and oil also. It is not only true that all gas and oil rocks are salt water rocks, but the converse has but very few exceptions; namely, all salt water rocks carry gas and oil as well.

What is the source of the salt water that the oil rocks contain? No other source than the sea in which they grew need be looked for. It is not necessary to find beds of rock salt at great depth to account for the enormous supplies of salt water with which all porous rocks are generally filled. They have been charged with this from the date of their formation.

These deep brines sometimes vary widely in composition. Hunt has suggested that the Silurian brines may represent the composition of the sea water of an earlier day, and notably different from the composition of salt water at the present time. An important fact in this connection is, that the quality of the brines varies with the rock from which they are derived. Limestone, for example, carries sulphurous and otherwise impure brines. The best brines are derived from sandstones.

Do these rocks reach the surface at any point? Certainly they do. They form constituent parts of the general series, and share all its fortunes. When found in outcrop they necessarily receive their portion of the rainfall of the regions to which they belong. This fresh water follows the stratum downward through its various flexures, blending at length with the salt water that fills the great mass of the rock.

When the porous rock in its salt water areas is penetrated at considerable depths by the drill, the brine invariably rises a greater or less distance in the well. Sometimes it overflows, but in other cases it falls short of reaching the surface by 50, 100 or 500 feet.

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* U. S. Geological Survey Report for 1886-87, p. 598.

The elevation that it reaches in one well it is likely to reach in others drilled near, indicating a common source and common pressure for all. What causes the salt water to rise in the wells? The answer is plain. The water is simply responding to artesian pressure, and thus is governed by the elevation of the outcrop of the porous stratum. The latter may be carried in mountain folds to considerable elevations, and thus give high pressure even when the wells are not excessively deep. But this porous stratum that we are considering has a small amount of oil and gas distributed through it; and it must be remembered that the rock never lies horizontal for any great distance, but has been variously flexed by the accidents of its geological history. Numerous folds, greater or less, are sure to be found in it. Where shall we look for the stocks of gas and oil above referred to? Under such circumstances as we have supposed, gravitation would have been sure to effect a separation of substances that differ as greatly in weight as the three that together fill the pores of this reservoir rock. Gravity in other words will drive forward the gas to the highest point or arch of the stratum. The oil will take its place next below, while to the salt water the remainder of the rock, or in reality almost its entire volume will be surrendered. All the low-lying regions of th porous stratum in particular will be flooded with salt water.

If now a well be drilled to the stratum along one of these lines where all three substances are located in close proximity to each other, it is plain to see that any one of the three substances, gas, oil or salt water, may be yielded to the drill, according to the location of the drill hole. If we drill into a trough of the rock we find the salt water following the drill as soon as the reservoir is reached, and very likely it will overflow the well. The cause of this ascent of the salt water we have already seen, and we must keep it clearly in mind. It is an artesian flow. But if the drill descends into the oil space, what is the result? The oil may rise and overflow the well with great force. Gas is sure to be mingled with it in such a case. Let us make one more supposition. Suppose the drill reach the gas area of the porous rock upon the summit of one of the unbroken arches we have already described. What are we to find now?

The phenomena of a high pressure gas well are among the most striking in the whole range of mining enterprise. The gas issues from the well-head with a velocity twice as great as that of a ball when it leaves a Minnie rifle. The noise with which it escapes is literally deafening. Exposure to it often results in loss of hearing on the part of those engaged about the well.

What is it that originates this indescribable force? What else do we need but the force we have just left, acting on the salt water which lies it may be but a few rods away from the gas well, and but a score or two of feet below in absolute depth?

It seems impossible to escape the conclusion that the pressure of the water column contained in the rock is responsible for all the effects of the outflows of gas and oil. Natural gas is compressed in the arch of the reservoir rock under the pressure of a water column just as artificial gas is compressed in the gas-holder of the city works.

What other explanations of these remarkable facts have been offered? But two have been put forward that deserve special consideration. Both will be briefly stated here.

One of them teaches that the rock pressure of gas is derived from its expansive nature. Solid or liquid materials in the reservoir are supposed to be converted into gas as water is converted into steam. The resulting gas occupies many times more space than the bodies from which it was derived, and in seeking to obtain the space demanded by the change through which it has passed it exerts the pressure which we note.

This view has no doubt elements of truth in it, even though it fails to furnish a full explanation. For the pressure of shale gas, it may be that no other force is required. But the theory is incapable of verification, and we are not able to advance a great way beyond the statement of it. Some objections to it will also appear in connection with facts that have been already stated.

The second of these explanations is without doubt more generally accepted than any other by those who have begun to think upon the question at all. It is to the effect that the weight of the superincumbent rocks is the cause of the high pressure of gas in the reservoirs. In other words, the term rock pressure is considered to be descriptive of a cause as well as of a fact. That a column of rock 1,000 or 1,500 feet deep has great weight is obvious. It is assumed that this weight, whatever it is, is available in driving accumulations of gas out of rocks that contain them whenever communication is opened between the deeply buried reservoir and the surface.

Is this assumption valid? Can the weight of the overlying rock work in this way?

Not unless there is freedom of motion on the part of the constituents of the rock, or, in other words, unless the rock has lost its cohesion, and is in a crushed state. If the rock retains its solidity, as Professor Lesley has shown, it can exert no more pressure on the gas that is held in the spaces between the grains than the walls of a cavern would exert on a stream of water flowing through it. The distinguished geologist named above has discussed this theory at some length, and has shown its entirely untenable character. (Annual report Penna. Survey, 1885.)

The claim that the Trenton limestone for example, where it is an oil or gas rock, exists in a crushed or comminuted state, is negatived by every fact that we can obtain that bears upon the subject. The claim is in fact entirely inadmissable and preposterous, but without this condition the theory fails.

Neither of these explanations of the rock pressure of gas and oil is found to be valid when subjected to any adequate examination, and we are left therefore to rely altogether upon the theory first stated, viz., that the flow of gas and oil depends upon the pressure of a water column, or in other words, every flowing gas well or oil well is in reality an artesian well. With the principles involved in ordinary artesian wells all intelligent persons are familiar, and it will therefore be easy for such to extend the applications of these laws to the cases now under consideration. An artesian water well obtains its supply from the syncline or trough of a folded section of rocks. Gas and oil on the contrary must come from the anticlines of the same or similar series.

DEMONSTRATION OF THE ARTESIAN THEORY.

The facts recently accumulated in the great gas-fields of northwestern Ohio and central Indiana afford a demonstration of the truth of the artesian theory of the rock pressure of natural gas, so far as these fields are concerned, and at the same time they render it probable that the cause which is found present here is equally operative in all other gas-fields as well.

The facts that enter into the demonstration come under the following heads, viz.: (*a*) the height to which the salt water rises in wet wells; (*b*) the density of the salt water; (*c*) the depth below the surface at which the water is found in drilling the wells; (*d*) the initial rock pressure of the gas when it is reached by the drill.

(*a*) As to the height to which the salt water rises in wet wells, there is not as much *exact* information as could be asked. A salt water well is by its very nature a failure, and the driller loses all interest in it from the time that its real character is made apparent; but we can sometimes obtain from his statements some clue as to the height to which the water ascends. The level at which the casing stands is an important point in the record of every well. When therefore the salt water is reported as rising 100, 200 or 300 feet in the casing, we can learn from such a record its approximate absolute height. The casings in the Findlay district are set at an elevation of 300 to 400 feet above tide. Salt water that ascends 100 or 200 feet into the casing is thus seen to have an absolute elevation of 400 to 600 feet above tide. When the surface of the ground in which the well is drilled is lower than in the field last named it becomes easier to get accurate figures. Along the shore of lake Erie in Ohio and in the Wabash valley of Indiana we obtain our most reliable data. The salt water rises nearly to the surface in the former district, and flows out in true artesian fashion from wells drilled in the last-named region, the surface of the valley being lower than that of the shore of Lake Erie.

As a result of all the observations made it can be stated that the strong and free flow of salt water from the Trenton limestone in the new gas-fields rises to approximately the same height in all wells, viz., to a level of about 600 feet above tide, whatever the elevation of the surface, or the depth below the surface at which the gas or oil is found.

This rise of the salt water must represent the height of some outcrop of the Trenton limestone in its porous condition. Such an outcrop is found on the shores of lakes Huron and Superior, and at approximately the same elevation as that to which the salt water rises in the new gas-fields, viz., 600 feet above tide. Fresh water finds access to the limestone in these outcrops; but its influence, while available for pressure, would not go far towards changing the character of the peculiar bitterns or brines that occupy this great sheet in its subterranean expansion.

(*b*) The specific gravity of the salt water of the Trenton limestone is high. Several determinations show a gravity of 1.1, and some samples are even higher. A column of fresh water one foot high and having a one square inch for the section weighs .43285 lb. avoirdupois. The weight of such a column of average sea-water is .445 lb; but twelve cubic inches of the Trenton brine counted at 1.1 weigh .476 lb. The weight may go as high even as .5 lb.

(*c*) The depth at which the gas or oil is found is the one element in the calculation that can as a rule be definitely ascertained. Coming as they do from the surface or near the surface of the Trenton limestone, the depth at which this great stratum is reached is a fact of universal interest and record in all the subdivisions of the fields.

(*d*) The remaining inquiry, that, namely, pertaining to the original rock pressure of the wells does not admit as a rule of determination or observation at the present time; and to learn the facts we must go back to the records of the earliest wells drilled in each portion of the productive territory. The pressure of a gas-field is reduced, and generally promptly, as soon as wells are multiplied to any considerable extent in it, and when we inquire for the facts of the pressure at the opening of the fields we frequently find more or less uncertainty. Gauges are not always reliable, and more than that they are not always promptly applied. Exaggeration also finds place in these early records to some extent.

In the list of early pressures, reported from the different portions of the gas-fields, the following figures are counted fairly trustworthy and fairly representative to the districts to which they belong.

Tiffin, Ohio	lb 650*
Upper Sandusky, Ohio	515
Bloom township, Ohio	465
Findlay, Ohio	450
St. Mary's Ohio	390
St. Henry's, Ohio	375
Kokomo, Indiana	328
Marion, Indiana	323
Muncie, Indiana	300†

These figures will now be combined with other data from the respective wells, and § to them will be added for comparison a column containing calculations of the pressure that should result from the following factors, viz., (*a*) an assumed ascent of the salt water to 600 feet above tide; (*b*) an assumed specific gravity of 1.1 for the salt water, which gives .476 lb to the foot in pressure. If the gas rock is found below tide, the figures representing this depth must be added to the 600 feet above tide to which the water rises. These sums will represent the effective water column. The rock pressure should be, according to theory, the product of the numbers thus resulting, and the weight of a column of Trenton limestone brine, one foot in height and one inch in section, which is .476 lb.

Location of wells.	Depth to gas. (feet.)	Relation of gas rock to sea level (feet below tide.)	Original pressure (lb.)	Calculated pressure (lb.) ‡
Tiffin, O.	1,500	747	650	1347 × .476=641
Upper Sandusky, O	1,280	478	515	1078 × .476=513
Bloom township, O.	1,145	395	465	995 × .476=476
Findlay, O.	1,120	336	450	936 × .476=445
St. Mary's, O	1,159	238	390	838 × .476=399
St. Henry's, O.	1,156	200	375	800 × .476=380
Kokomo, Indiana	936	98	328	698 × .476=332
Marion, Indiana	870	78	323	678 × .476=323
Muncie, Indiana	900	0§	300	600 × .476=286

The agreement between the last two columns of the table affords a demonstration of the principal cause of the rock pressure of Trenton limestone gas. It is due to the weight of the salt water that occupies the porous rock jointly with itself, though by a very unequal partnership, and the water pressure in turn is unmistakably of artesian origin. ¶

A few obvious conclusions that follow the acceptance of the artesian theory will find appropriate place at this point and will conclude the discussion of this particular subject.

1. The supplies of gas and oil are seen to be definitely limited by this theory of rock pressure. If a salt water column is the propelling force, it is idle to speculate on constantly renewed supplies. The water advances as the gas or oil is withdrawn, and the closing stage of the oil rock is, as already pointed out, a salt water rock.
2. Other things being equal, the rock pressure will be greatest in the deepest wells. The deeper the well the longer the water column.
3. Other things being equal, the rock pressure will be greatest in districts the gas or oil rock of which rises highest above the sea in its outcrops. The 800 pounds of rock pressure in Pennsylvania gas wells, as contrasted with the 400 pounds pressure of Findlay wells, can be accounted for on this principle.
4. Where both oil and gas are found in a single field, the first sign of approaching failure will be the invasion of the gas rock by oil, or of the oil rock by salt water. Salt water follows the gas directly however in a great many fields without the intervention of an oil horizon.
5. This explanation shows the lack of all foundation for the views advanced from time to time by sciolists, wrongly called scientists, as to imminent dangers that are to result from air entering the gas rock, and there forming an explosive mixture, or from extensive subsidence of the regions from under which the gas has been withdrawn. Such notions whenever advanced are sure to obtain wide currency through the newspapers, but they are utterly foolish, and so far as they disquiet the minds of the ignorant are mischievous.‖

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* The gauge used in this well read only to 600 lb., but the index indicated an excess of 50 lb.

† Reported as "less than 300 lb."

‡ At tide level. §Add 600 to figures in third column, and multiply by .476 lb.

‖ Prof. Orton in the Geological Survey of Kentucky, 1891, pp. 83-91.

Reference has already been made to the fold or uplift which crosses the county of Essex in a north and south course in the vicinity of the Kingsville gas field. But in considering the relation of this arch to the presence of gas we should take account of the opposing fact, that all the Silurian formations in southern Ontario dip in a southwesterly direction, and that they rise again on the other side of lake Erie; whence it follows that they form a great synclinal fold having an east and west axis, but the line of which has not yet been located. Now the borings in Essex are not sufficiently numerous nor the records of them sufficiently exact to make one sure of his ground in estimating the value of opposing theories of occurrence. The synclinalists and the anticlinalists may wage war indefinitely on this field, or at all events until the formations have been more carefully and thoroughly explored by the drill, although at present the anticlinal theory would seem to be in the greater favor.

In the Niagara peninsula, on the other hand, circumstances are more favorable to the synclinal theory, or perhaps the monoclinal, for there the gas-producing rocks have a uniform dip southward, without sign of an arch fold so far as known. From the outcropping of the Medina, Clinton and Niagara formations along the face of the Niagara escarpment to the line of borings along the shore of lake Erie the dip is computed to be about 25 feet per mile, although there is no absolute agreement found in the records. At Port Colborne, near the lake shore, the Corniferous formation has a depth of 13 feet, and 705 feet below it the Medina is reached, which is the principal gas rock of the district.* At Black Rock near Buffalo the Corniferous is 625 feet above the level of the sea; at Fredonia, 38 miles to the southwest, it is 315 feet below; while at Conway, in Pennsylvania, 81 miles southwest of Fredonia, it is 2,900 feet below, the average dip of this section being 32 feet per mile. At the town of Erie, on the south shore of lake Erie and 44 miles west of Fredonia, the Corniferous formation is 725 feet below the sea, the average dip being only 9 feet. But at Wheatland, 64 miles south of Erie, it is 2,517 feet below tide, the average southern dip being 28 feet per mile. Wheatland is 32 miles west of Conway, so that the formation rises in that section at the rate of 12 feet per mile. At Akron in Ohio, 54 miles west of Wheatland, the Corniferous is 925 feet below the sea, showing an average rise in this section of 30 feet per mile; and at Wellington, 37 miles west of Akron, it is only 174 feet below, showing an average ascent of 20 feet per mile for this section. But at Columbus, the capital of Ohio, the formation rises to 630 feet above tide, or 5 feet higher than at Black Rock. At Pittsburgh, about 60 miles south of Conway, a well was bored to the depth of 3,733 feet below sea level without reaching the Corniferous formation, and assuming that it does not thin out and disappear before reaching that point the dip from Black Rock to Pittsburgh, a distance of about 180 miles, is not less than 4,358 feet.†

The Medina formation, much thinned out, is found to lie up against the eastern slope of the Cincinnati arch in Ohio, and therefore there is no reason to doubt that it underlies the Corniferous in that direction for its whole extent, dipping southward at the same angle and rising with it westward. But it is also found to crop out in the mountain chains of southeastern Pennsylvania (where the Corniferous is wanting), and with a thickness of 1,500 to 1,900 feet forms there a succession of folds which rise in some ranges to 2,600 feet above the sea.‡ Southward it is found to rise to the surface in the mountains of Tennessee. The Medina formation is thus shown to be a great synclinal trough, whose deepest part must be nearly if not fully a mile below the gas-producing horizon of it in the county of Welland, and whose highest fold or outcropping must be 2,800 feet above that horizon.

How then can the anticlinal theory or the theory of hydrostatic pressure apply under such conditions to the existence of natural gas or oil in the Medina formation along the north shore of lake Erie, within 18 miles of its outcropping along the Niagara escarpment? And how is the barren belt between that outcropping and the line of producing wells to be accounted for? These questions may possibly be answered after the Niagara peninsula has been more thoroughly explored by the drill and when accurate records of the wells have been obtained. Or more likely a solution of the problem may be found in a study of the conditions which existed before the occurrence of the disturbances which produced the foldings, subsidences and other alterations of level which now exist in the gas-yielding strata, and ages before the Silurian escarpment had an existence, when the Niagara, Clinton and Medina beds still extended northward over a large portion of the area now covered by the waters of lake Ontario, and when their area southward was a wide and level plain. At what time the Clinton limestones and the Medina sandstones became reservoirs of gas, and how the changes of level which took place before and at the time the Appalachian mountains were raised affected those reservoirs, can be at best only subjects of ingenious speculation.

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* McRae's record of drilling; see *ante* pp. 129-130.

† Geological Survey of Pennsylvania, Carll's report, 1890.

‡ *Ib.* I 3, the Geology of Huntingdon County.

THE ECONOMIC VALUE OF NATURAL GAS.

The many uses to which natural gas has been applied in the United States prove it to possess a high economic value; but obviously enough producers and consumers have gone upon the assumption that the supply was not only abundant and cheap, but inexhaustible also. As an article of fuel it possesses for many purposes great advantages over coal or wood, notably as regards cheapness, application and cleanliness. It has therefore been in great demand wherever supplies have been obtained, and in some instances pipe lines have been laid to convey it to distances of 70 and even 100 miles. It has also been very wastefully used in rolling mills, brick yards and other places, with the result that many wells which a few years ago yielded millions of cubic feet per day are already very greatly reduced in capacity, and in almost all of them there is a noticeable decrease in pressure. The following extracts will show how American authorities regard the economic aspect of natural gas.

One pound of coal weighs 25 cubic feet of gas.

One pound of coal has a fuel value of 7½ cubic feet of gas.

In 1885 300 miles of gas mains to the factories and dwellings of and around Pittsburgh furnished heating power equal to 2,000,000 bushels of coal per month=1,000,000 tons of coal per annum.

Before the end of 1885 one gas company in Pittsburgh reported 335 miles of pipe of all sizes, displacing the use of about 10,000 tons of coal per day, or 3,650,000 tons per annum, the consumption growing rapidly.

Probably 5,000 men will be dispensed with.

The waste at the wells being at first enormous, there was no economy at the works; but of late precautions have been taken to economize the supply.

The gas is odorless, because free from sulphur, etc.

This purity must be taken into account in estimating its value as a fuel. It makes better iron, steel and glass than can be made with coal gas or coal.

It makes steam more regularly, because there is no opening or shutting of doors, and no blank spaces left on grate bars for the entrance of cold air. When properly arranged its flow regulates the steam pressure, leaving the engine man nothing to do but watch the steam gauge.

Boilers last longer and fewer explosions result from unequal expansion and contraction when cold air strikes hot plates.

The *theoretical value* of gas as compared with coals is stated in the report of S. A. Ford, chief chemist of the Edgar Thomson steel works, 210,069,604 *heat units* in 1,000 *cubic feet of gas* weighing 38 pounds avoirdupois, while the same weight of carbon contains 139,398,896.

Therefore 1,000 cubic feet of gas,=57.25 pounds carbon, or
Coke, (at 90 per cent carbon) 62.97 pounds, or
Bituminous coal, 54.4 pounds, or
Anthracite coal, 58.4 pounds.*

I take this opportunity to express my opinion in the strongest terms, that the amazing exhibition of oil and gas which has characterized the last twenty years, and will probably characterize the next ten or twenty years, is nevertheless not only geologically but historically a temporary and vanishing phenomenon—one which young men will live to see come to its natural end. And this opinion I do not entertain in any loose or unreasonable form; it is the result of both an active and a thoughtful acquaintance with the subject. From the time that Colonel Drake sunk the first well on the plains of Titusville, I have professionally participated in the history of the oil and gas developments, and believe myself to be familiar with whatever has been said and done in the premises; and there does not remain upon my mind a shadow of doubt respecting the practical extinction, in the comparatively near future, of that great commerce in oil of which the people of Pennsylvania have taken so little advantage when they might have accumulated from its sale in all quarters of the world a provision of moneyed wealth unheard of in the history of our race. The opportunity is indeed still offered; but it is steadily diminishing, and in a few years it will entirely pass away never to return again. For I am no geologist if it be true that the manufacture of oil in the laboratory of nature is still going on at the hundredth or the thousandth part of the rate of its exhaustion. And the science of geology may as well be abandoned as a guide if events prove that such a production of oil in western Pennsylvania as our statistics exhibit can continue for successive generations. It cannot be; there is a limited amount. Our children will merely, and with difficulty, drain the dregs.

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* J. P. Lesley, State Geologist of Pennsylvania, in Trans. Am. Inst. M. E. vol. xv. pp. 527-8.

I hold the same opinion respecting gas, and for the same reasons; with the difference merely that the end will certainly come sooner, and be all the more hastened by the multiplication of the gas wells, and of the fire boxes and furnaces to which it is led.*

Natural gas in the favored regions has been a great boon to the open-hearth-steel manager; he no longer has to spend a very valuable portion of his time "poking the gas-man to poke his fires." The gas is carried to the furnace in an even flow through a three-inch gas pipe, which branches off to both ends of the furnace in two-inch pipes. The delivery and reversing of the gas are regulated by ordinary globe gas-valves placed in the circuit. The ends of the pipe are encased in the brick work, and open into the flats of each end of the furnace from the opposite side walls by leaving out the space of a header in the fire-brick at the ends of the pipe. This gaseous fuel is not diluted to fully 60 per cent. of its entire bulk with inert nitrogen, as is Siemens gas, which has to be conducted in pipes of four feet diameter to one of the gas-regenerators to be pre-heated. Natural gas is conducted directly to the ports of the furnace, as it was found that pre-heating decomposed it and soon filled the checker-work of the gas-regenerators with deposited carbon. The use of cold gas is much more than compensated for in the heat produced by the combustion of the concentrated fuel, and by avoiding the large amount of nitrogen which is present in Siemens gas. Natural gas melting furnaces are now built so that both of the regenerators at each end of the furnace are connected with the air-inlet valve, or they are built with only one regenerator at each end of the furnace for pre-heating the air. In this case the air-valve and air-regenerators are built larger, with 60 per cent. greater capacity than when using Siemens gas. Natural gas is supplied in the service-mains to melting furnaces in the vicinity of Pittsburgh with a pressure of about eight ounces; and this pressure is adjusted in the service-pipes by regulators, ordinarily furnished to the plants by the natural gas companies, and placed with their connection to their mains at some suitable point about the plant. The pressure, as regulated by the valves at the large lash furnaces, is at present only about one ounce or an inch and a half of water pressure, as the gas goes into the melting furnace. The lighter the pressure, so long as the flow is kept uniform and steady, the better the combustion and the more intense the heat. The steady uniform flow of natural gas has made it peculiarly applicable as a fuel for melting in open-hearth furnaces and has been a very potent cause of the growing reputation for regularity and uniformity, as well as for superiority in other ways, of the open-hearth steel made in the natural gas districts. †

Postulating that every gas pool contains a fixed quantity of gas already stored and awaiting liberation, it is evident that the life of a pool does not depend so much upon the quantity of gas accumulated as upon the comparative rapidity with which it is allowed to escape. Given two deposits of equal capacities and pressures—if A suffers depletion by 10 wells in five years B ought to be equally depleted by 50 wells in one year. In fact B should be most exhausted; for having five times as many vents as A the gas need travel but a short distance in the rock to reach an outlet, and hence suffering less retardation from friction would escape more rapidly. . . .

It is *not claimed* in any part of this report (nor indeed in any previous one) that the oil and gas fields of Pennsylvania *are exhausted*, nor that they will be completely drained in *a very few years*, although speaking comparatively and with reference to geologic time, the latter expression might be allowable. But it *is* claimed that they have been excessively and wastefully depleted, that all the fully developed pools are surely on the decline, that every pool depleted lessens by just so much the area to be profitably drilled, and every year's unsuccessful prospecting outside of the productive belts and of deep drilling within them makes the outlook for the discovery of new oil horizons less hopeful, that from this time forward we have no reasonable ground for expecting or even hoping that these oil fields will continue to supply the world with cheap light as they have in the past, and that therefore it is wise to pause and consider how best to husband our remaining resources and make the most of them.

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* J. P. Lesley, State Geologist of Pennsylvania, in Trans. Am. Inst. M. E., vol. XIV. pp. 621.

† Alfred E. Hunt of Pittsburgh in Trans. Am. Inst. M. E., vol. XVI. p. 696.

And when we remember that the piping of natural gas on a large scale is now only in its fifth year; that the demands for daily consumption have grown to over 500,000,000 cubic feet per day, and are still increasing; that nearly all the gas pools now in sight show evidences of gradual failure; and that a large proportion of the available gas territory in the state has already been more or less thoroughly prospected, we are forced to the conclusion that the continuance of gas supplies is even less certainly assured than the continuance of oil supplies. At any rate the time has evidently come when the natural gas companies should insist upon a fair compensation for the gas delivered and enforce economy in using it, for it is too valuable a product and too evanescent to be recklessly wasted and consumed as it has been in the past.*

In the manufacture of glass, of which there is an immense quantity made in Pittsburgh, I am informed that gas is worth much more than the cost of coal and its handling, because it improves the quality of the product. One firm in Pittsburgh is already making plate-glass of the largest sizes equal to the best imported French glass, and is enabled to do so by this fuel. In the manufacture of iron, and especially in that of steel, the quality is also improved by the pure new fuel. In our steel rail mills we have not used a pound of coal for more than a year, nor in our iron mills for nearly the same period. The change is a startling one. Where we formerly had ninety firemen at work in one boiler-house, and were using 400 tons of coal per day, a visitor now walks along the long row of boilers and sees but one man in attendance. The house being whitewashed, not a sign of the dirty fuel of former days is to be seen, nor do the stacks emit smoke. In the Union Iron Mills our puddlers have whitewashed the coal bunkers belonging to their furnaces. Most of the principal iron and glass establishments in the city either are to-day using this gas as fuel or are making preparations to do so. The cost of coal is not only saved, but the great cost of firing and handling it; while the repairs to boilers and grate-bars are much less.†

In his last report on the geology of Ohio Prof. Orton devotes a chapter to the utilization of natural gas in that state, and some of the conclusions to which the facts and discussions he presents would lead are summarized as follows:

1. Natural gas finds its highest and most valuable use as domestic fuel. It is here that it does the greatest good to the greatest number. In all our dealings with it this fact should be kept constantly in view. To maintain it for the longest period for this service is our highest interest in relation to it.
2. If there is any use for which gas should be sold below the price of the fuel which it supplants, it is its use in cooking stoves. The less fortunate members of the communities should be the favored ones in this regard. For the gas used in heating there is no occasion to mark the price below the cost of coal; neither is there any justifiable demand for a discount on gas bills increasing according to the number of fires supplied. If a sliding scale is introduced it might perhaps better be made to slide the other way, charging consumption beyond the average at a higher rate.
3. An advance in price on the part of municipal corporations for all the uses that they undertake to supply is their proper policy. The price at which they have furnished it hitherto leads to undervaluing and wasting the gas. The supply will do the towns more good by serving them longer if they are required to pay a higher price for the gas.
4. All gas should be sold by measured volume. Meters and gauges ought to be introduced everywhere. No adequate motive to economy can be brought to bear on many consumers until they are obliged to pay at a proper rate for what they use.
5. Next to domestic use the use of gas in the production of steam power is to be counted the most suitable application of it. Comparatively small amounts of it are required for this purpose, and great convenience and economy result therefrom. The most skillful use of it will find a rate of fifty feet to 1-horse-power sufficient, but a use of more than eighty feet to 1-horse-power should not be allowed, even if the user is willing to pay for it.
6. Of the various manufacturing uses in which the gas is applied as fuel proper, glass-making has probably the best rights. It contributes larger returns to the community in the shape of wages than other like industries. While its introduction into northern Ohio has been greatly overdone, and while much of it has been accomplished by the exercise of a mistaken policy, it should be maintained as long as possible. To this end economy should be everywhere enforced. The window-glass works might perhaps be required to introduce coal into their furnaces for melting at an early day, reserving gas for the stages of blowing and flattening.
7. From certain uses to which gas is now largely applied it should be at once entirely withdrawn. It is a great wrong to the community to allow it to be used in burning common building brick and in calcining limestone. These processes consume large quantities

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* John F. Carll in Geological Survey of Pennsylvania, vol. I5. pp. 11 and 23.

† Andrew Carnegie in Macmillan's Magazine January, 1885, p. 212.

of gas and make no returns except to their owners. For these uses wood and coal are good enough. The industry that consumes gas in by far the largest amount is iron working. It is a grievous mistake on the part of any community or company to allow a rolling mill access to its gas field. An ordinary mill uses as much gas every day as several thousands of families would consume, and the returns to the common good by such an application are small compared with any other ways of using the gas. Even though a rolling-mill stands ready to pay as much per thousand feet as the small consumers pay, it ought not to be supplied. If it is willing to do this it shows that there is not enough charged for the gas. It may be to the interest of the gas company to get its money back rapidly, it is true, but the community has interests, if not rights as well, that should not be overlooked in relation to this supply. The state interferes when an oil well is left without being plugged, or when a gas well is allowed to blow into the air without use. Why? Because these precious stocks of mobile power are fitted to do good to great numbers of the people, and no man has a right to take any action by which they shall be needlessly wasted. A like reason could perhaps be found for forbidding entirely the use of gas for the rough work that has been named above.

8. If economy is everywhere insisted on and practised, the last days of natural gas in Ohio may be its best days. If, on the other hand, the wasteful policy that is now so largely in force should be maintained, there is sure to be, and at no very distant day, great disappointment and reaction in the communities that have obtained it and that have been stimulated by its acquisition to what may prove an unhealthful activity.

9. Natural gas is merely a transient phase of the stored power of the earth. It is folly to talk of its taking anything like a permanent place in the work of the world. The claim that it can do so springs only from enthusiasm or sciolism. There is in reality but little of it, and this little is found in but very limited regions and cannot last long whenever its utilization is undertaken by the eager and masterful activities of our day.

10. Natural gas has a very important work to do. It should prepare the world for something much better than itself. It is giving an object lesson to great communities as to the advantage of gaseous fuel, and it can hardly be that this lesson will be given in vain. The exemption from the soot and dust inseparable from the burning of bituminous coal in our cities and the positive addition that gaseous fuel makes to the comfort and convenience of the entire community when used as domestic fuel and as a source of steam power are results in themselves too valuable to be abandoned when these small and treacherous stocks of buried power are exhausted. The conversion of the coal now burned in a large city into gas before being used would result in an immense economy in fuel, besides affording the incidental advantages alluded to above, and this economy of stored power is an object to which the civilized world will soon be obliged to address itself good earnest.*

We in Ontario should be able to learn some valuable lessons from the experiences of our neighbors as to the uses and economies of so important a mineral as natural gas. In Essex and the Niagara peninsula there is good reason to believe that we possess a large supply of it, and in the absence of any other mineral fuel which might be utilized in manufactures as well as for domestic purposes the wasteful or economic use of it is a matter of no little importance. In Essex the bulk of the gas supplies light and heat for the villagers, and in the Niagara peninsula it renders a like service to a small extent. But by far the greater part of the product of wells in the latter district is conveyed across the river to supply a cheap fuel to the citizens of Buffalo. This is a questionable policy in so far as the interests of Ontario are concerned. It is parting with a valuable asset in an extravagant way, and when it is gone there is an end of it.

EXPERT OPINION ON THE NIAGARA PENINSULA.

Mr. C. A. Ashburner of the Pennsylvania Geological Survey was consulted by citizens of St. Catharines as to the possibility of obtaining gas in the vicinity of that city in sufficient quantities to permit of its profitable distribution through the city for manufacturing purposes. The following account of the results obtained there is taken from a paper read by Mr. A. before the American Institute of Mining Engineers.

Immediately subsequent to the erection of the Thorold well derrick, and before drilling had been commenced, I ventured an opinion that the geological structure of the strata at Thorold absolutely precluded the existence of gas there in commercial quantity, and that the drilling of this well would not settle the question conclusively, because even if a gas pool did exist in the Trenton strata under the eastern portion of the Ontario peninsula there was no hope of encountering it in the Thorold well.

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* Prof. Orton in the Geological Survey of Ohio, 1890, pp. 278-80.

The St Catharines well was located at a point where there was apparently a very low but perceptible dome in the strata, caused by the intersection of two broad and comparatively flat anticlinals, one having a general north-northeast and south-southwest direction, and the other having a general northwest and southeast direction.* After setting the drive-pipe in this well in the alluvium clay, drilling was commenced in the upper portion of the Medina sandstone strata 130 feet vertically below the top of the Medina formation. The upper part of the Medina is boldly exposed at several points southeast of St Catharines.

The St. Catharines well was drilled to a total depth of 2,200 feet. The geological horizon separating the Medina sandstone from the underlying Hudson River shales was pierced at a depth of 720 feet. The Trenton limestone was struck at a depth of 1,505 feet. The bottom horizon of the Trenton† was passed through at a depth of 2,182 feet, drilling being stopped at a depth of 2,200 feet after 18 feet of the Calciferous sandstone had been pierced.

Combining the sections of the Port Colborne and Buffalo wells with that of the St. Catharines well, the following is a general section of the strata:

	Devonian.	Thickness.	Depth.
No. VIII.	Corniferous limestone	25 feet	to 25 feet
No. VII.	Oriskany sandstone		Wanting.
	Silurian.		
No. VI.	Lower Helderberg limestone		Wanting.
	Water lime		Wanting.
	(The Buffalo cement bed is one of the top strata of the Salina, and does not belong to the water-lime group, as popularly supposed.) Salina or Onondaga limestone and shales	500 feet	to 525 feet.
	Niagara limestone	155	" 680 "
	Niagara shales	70	" 750 "
No. V.	Clinton limestone and shales	50	" 800 "
No. IV.	Medina sandstone and shales	850	" 1650 "
	Oneida sandstone and conglomerate		Wanting
	Silurio-Cambrian and Cambrian.		
No. III.	Cincinnati {Hudson River shales Utica shales and slates}	785 feet	to 2,435 feet.
No. II.	Trenton limestone Black River limestone Birdseye limestone Chazy limestone Quebec limestone	677	" 3,112 "
	Calciferous sandstone	18	" 3,130 "

The upper 930 feet of this section has been compiled from facts obtained from the Buffalo, Getzville and Port Colborne wells, and from a study of the strata along the Niagara river gorge from lake Erie to lake Ontario . . . .

The lower 2,200 feet of the above section were classified from over 200 specimens of the drillings of the St. Catharines well and from a number of general facts reported of the strata pierced by the Thorold well.

In the St. Catharines well several small pockets of gas were found at a number of places in the Medina, Hudson, Utica and Trenton strata, and about 500 feet below the top of the Trenton limestone, at a point more than 1,500 feet below ocean level. a pool of gas was pierced which produced on an average about 100,000 cubic feet of gas per day for several days, but was soon exhausted.

A careful mineralogical and chemical examination of the drillings from the Trenton limestone pierced by the St Catharines well does not give promise of the existence of gas in commercial quantities in the Trenton limestone anywhere under the eastern portion of the Ontario peninsula, unless the character of the rock changes very materially from that found in the St Catharines well.

This section of the eastern portion of the Ontario peninsula, which is now published for the first time, is not only of great importance as bearing upon the occurrence of natural gas in the district, but one of the most important sections relating to American geology, since it conclusively settles the stratigraphical structure of the Niagara region, whose geology has been studied by more geologists and for a longer period than that of any district on the continent. On account of the low southern dip of the strata (an average of 35 feet per mile), the lack of good exposures, except from the falls north to the mouth of the Niagara river, and the fact that lake Ontario cuts off the opportunity of observing the basset edges of the strata north of the river, it was impossible to determine absolutely the thickness of most of the strata from the Corniferous limestone down to the Trenton limestone except by drilling of wells; the records of the Buffalo, Getzville, Port Colborne. Thorold and St. Catharines wells, studied independently and conjointly, have afforded for the first time this favorable opportunity.

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* "There are no such things as *cross anticlinals*, any more than there are *cross billows* on the surface of the ocean during a storm, the whole system of billows being arranged in one direction in nearly parallel lines, but each billow being composed of a multitude of waves arranged along a line." J. P. Lesley in the Report of the Pennsylvania State Geologist for 1885, p. xxix.

† No attempt has been made to subdivide the limestone strata between the Utica shales and the Calciferous sandstone into the Trenton, Black River, Birdseye, Chazy and Quebec; the drillings between the Utica and Calciferous being so nearly alike, the entire 677 feet of limestones have been grouped for convenience under the name of Trenton.

Upon the facts contained here and in my Duluth and Buffalo papers already referred to, the following conclusions bearing upon the occurrence of natural gas in the eastern Ontario peninsula are based:

CONCLUSIONS.

1. The gas in the Buffalo wells, in quantities sufficiently great to be profitably utilized. comes from the lime shales occurring from 15 to 60 feet above the bottom of the Salina formation. Small amounts of gas, but not in commercial quantities, were also found in the Niagara limestones from 45 to 80 feet below the top of the Niagara formation.

2. The top of the Trenton limestone under the city of Buffalo should be encountered by a well drilled in the vicinity of the Buffalo Cement Company's present wells, at a depth of 2,400 feet, more or less.

3. Little hope can be entertained of finding gas in commercial quantities in the Trenton limestone under the eastern Ontario peninsula.

4. In the southern portion of the Ontario peninsula, east of a line from Hamilton to Port Dover, natural gas, in quantities sufficiently great to be profitably utilized near the wells can be expected to be found in special localities where the local geological structure is favorable to its existence, in the following geological horizons: (1) From 15 to 75 feet above the bottom of the Salina formation. (2) In parts of the Niagara limestone and shales; notably in the upper part of the Niagara limestone. (3) In the upper part of the Medina sandstone. (4) In the Hudson River and Utica shales and sandstones. The most promising horizons are those in the upper part of the Medina and lower part of the Salina formations.

5. It cannot be expected that gas would exist in any of the strata in commercial quantity unless the gas-reservoir stratum is covered by at least 400 feet of superincumbent strata; nor can it be expected that gas will be found in any two or three different strata in the same well.*

Yet the accounts of recent borings show that gas has been found in two or three different strata in the same well in the Niagara peninsula.

In volume XVII. of the Transactions of the American Institute, p. 401, the same authority furnishes the following data on the thickness of formations in the Niagara peninsula:

THICKNESS OF THE FORMATIONS.

I have recently made a careful geological examination of the Ontario peninsula between lakes Erie and Ontario; and the facts obtained during this survey, studied in connection with the records of the three wells recently drilled at Port Colborne (at the southern end of the Welland canal, 17 miles west of Buffalo), enable me to determine the thickness of the Salina strata.

The third well at Port Colborne was drilled 1,500 feet. Carefully collected specimens of the strata passed through were kept by Mr. O. C. Richardson, from whom duplicate specimens were obtained. From these specimens I have gathered sufficient facts to enable me to construct a detail section of the well, of which the following is a summary:

			Thickness.	Depth.
	Erie Clay	feet	12	12
No. VI.	Salina limestone and shales		473	485
	Niagara limestone		155	640
	Niagara shales		70	710
No. V.	Clinton limestone and shales		50	760
No. IV.	Medina sandstone and shales		740	1,500

The top of this well is 587 feet above tide level; the top of the Medina sandstone was struck at a depth of 760 feet; and, judging from the character of the strata passed through near the bottom of the well, I do not believe the drill stopped very far above the geological horizon between the bottom of the Medina shales and the top of the Hudson River shales, so that the thickness of the Medina formation is probably not far from 900 feet.

The Clinton limestones and shales are exposed in the Government quarry back of the Riordan paper mills at Merritton, 9 miles west of Lewiston. Immediately overlying the Clinton rocks in this quarry is an exposure of the Niagara shales, the bottom of which is 490 feet above tide. The same geological plane (that between the Clinton and Niagara formations) in the Port Colborne well No. 3 is 123 feet below tide; hence the average southern dip of the strata from Merritton to Port Colborne (17½ miles) is 35 feet per mile.

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* Trans. Am. Inst. M. E. vol. XVIII. pp. 300-3.

This result, considered in conjunction with the scattered geological data collected on either side of the Niagara river between Buffalo and Lewiston, and with the records of the Buffalo wells, leads to the conclusion that the bottom of the Niagara shales was pierced by the drill in the Buffalo deep well at a depth of 710 feet, and that the top of the Medina sandstone was struck at a depth of 760 feet, so that the drill in this well was stopped in the Medina formation 545 feet below its upper limit. In this well I would assign a thickness of about 475 feet to the Salina, about 235 feet to the Niagara (both limestone and shales), and 50 feet to the Clinton.

VALUE OF RECORDS OF BORINGS.

On the value of accurate records of borings John F. Carll of the Pennsylvania Geological Survey says:

> Every land-owner should make it a point to preserve at least one complete and reliable record of the drillings on his farm, giving the depth, thickness and character of each stratum from the top to the bottom of the deepest well. This record should be kept from actual measurements, made wherever a change of rock occurs and recorded on the spot at the time in a book kept for that purpose; and not be written up, as is too often the case, when the well is completed, when it is made to conform to some general formula which the driller has worked out from his experiences on other wells.*

Whoever has tried to get a record from drillers or the owners or managers of wells knows how hard it is to procure a satisfactory one. In most cases the record is given from memory, and all the figures are "about it and about," like the Persian poet's description of great argument between doctor and saint. Besides accurate figures, samples of the drilling should be kept in glass bottles provided for the purpose, each sample to be labeled with the depth from which it has been taken. But then there is such a thing as doctoring the record in the interest of the contractor, that he may get another contract; and there is such a thing as concealing it, so that other operators may not profit by the information which it could supply.

AN ACT TO PREVENT THE WASTING OF NATURAL GAS.

Approved by the Lieutenant-Governor, April 14, 1892.

Her Majesty, by and with the advice and consent of the Legislative Assembly of the Province of Ontario, enacts as follows:

Natural gas not be allowed to escape from unused wells.

1. From and after the passing of this Act any person or corporation, and each and every of them in possession, whether as owner, lessee, agent or manager, of any well in which natural gas has been found, shall, unless said gas is sooner utilized, within a reasonable time, not, however, exceeding two months from the completion of said well, in order to prevent the said gas wasting by escape, shut in and confine the same in said well until such time as it shall be utilized; provided, however, that this section shall not apply to any well while it is being operated as an oil well.

Plugging abandoned wells.

2. Whenever any well shall have been put down for the purpose of drilling or exploring for gas, upon abandoning or ceasing to operate the same, the person or corporation in possession as aforesaid shall, for the purpose of excluding all water from the gas-bearing rock, and before drawing the casing, fill up the well with sand or rock sediment to a depth of at least twenty feet above the gas-bearing rock, and drive a round seasoned wooden plug, at least three feet in length, equal in diameter to the diameter of the well below the casing, to a point at least five feet below the bottom of the casing, and immediately after drawing the casing shall drive a round, seasoned wooden plug at a point just below where the lower end of the casing rested, which plug shall be at least three feet in length, tapering in form, and of the same diameter at the distance of eighteen inches from the smaller end as the diameter of the hole below the point at which it is to be driven. After the plug has been properly driven there shall be filled on top of the same sand or rock sediment to the depth of at least five feet.

Penalties for contravention of Act.

3. Any person or corporation contravening any of the provisions of the first or second sections of this Act shall be liable to a penalty not exceeding $100 for each and every violation thereof, and to the further penalty of $25 for

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* Annual Report for 1885, p. 77.

each thirty days during which said violation shall continue; and all such penalties shall be recovered, with costs of suit, in a civil action or actions in the name of any person or persons who may sue for the same.

Entry on lands to close wells.

4. Whenever any person or corporation in possession of any well in which gas has been found shall fail to comply with the provisions of the first section of this Act within the time therein set forth, any person or corporation lawfully in possession of lands on which the well is bored, or of lands situate, adjacent to or in the neighbourhood of said well, may after ten days' notice in writing to the owner of the well or his lessee, agent or manager, enter upon the lands upon which said well is situated and take possession of said well from which gas is allowed to escape or waste, in violation of said first section, and tube and pack said well and shut in said gas, and may maintain a civil action in any court of this Province against the owner, lessee, agent or manager of said well, and each and every of them, jointly and severally, to recover the cost thereof, in addition to the penalties provided by section 3 of this Act.

Power to take possession of well and plug same.

5. Whenever any person or corporation shall abandon any gas well and shall fail to comply with the second section of this Act, any person or corporation lawfully in possession of lands adjacent to or in the neighbourhood of said well may after ten days' notice in writing to the owner or his lessee, agent or manager, enter upon the land upon which said well is situated and take possession of said well and plug the same in the manner provided by the second section of this Act, and may maintain a civil action in any court of this Province against the owner or person abandoning said well, and every of them, jointly and severally, to recover the cost thereof, in addition to the penalties provided by the third section of this Act.

Commencement of Act.

6. This Act shall take effect on, from and after the first day of May, 1892.

THE MINERALS OF ONTARIO.

An Address to the Students of Upper Canada College, May 6, 1892.

It is about thirty years since in a country school section in one of the Lake Erie counties I gave my last talk to boys and girls. Never much gifted in that way, I feared to trust myself to make an oral address in a room of College boys, and especially upon a subject that demands care in the statement of facts. Therefore I have thought it wise to speak to you from paper.

Thirty years is a long time in the life of a man, as the life of man goes; a long time to be spent in well or ill doing. In that school section where I taught a generation ago I am reminded that there were forty-eight or fifty persons each of whom had then reached my present time of life, or over. They were men and women in the vigor of their days and strength, who had cut for themselves homes out of forests of oak and maple and walnut and chestnut, and a hardier or healthier lot of men and women you could not find in the whole of broad America. Where are they to-day? The answer is the old, old story. Of all but two of their number it has now to be said that there are other toiling hands where theirs have ceased from their labors, and there are other weary feet where theirs have completed their journey. It is the old, old story. "One generation goeth, and another generation cometh; and the earth abideth forever."

You have read of Waterloo, an event of seventy-seven years ago. You recall the brilliant cavalry attacks of Marshal Ney upon Wellington's fifth brigade, and Wellington's unleashing order at sunset when arose that stern and appalling shout which the British soldier is wont to give upon the edge of battle, and which no enemy ever heard unmoved. In that fifth brigade which withstood and repulsed the charges of Marshal Ney's horse, and joined in the shout when the order to advance was given, was an Irish soldier, Maurice Shea, one of the 24,000 of English, Irish and Scotch who shared in the glory of that fateful day. Maurice Shea was the last survivor of the 24,000, and his death at the age of 97 took place a few weeks ago in the town of Sherbrooke, in the province of Quebec[*]. A few days later there died in France the last survivor of the marines who fought and lost under Villeneuve off cape Trafalgar. Eighty-seven years—nay seventy-seven years—is a long time in the life of a man, and such last survivors as those of Waterloo and Trafalgar are not often met with in human annals, so fleeting is our stay upon this world's stage.

In his book on Nineveh and its Remains Layard observes that a deep mystery hangs over Assyria, Babylonia and Chaldea. With these names, he says, are linked great nations and great cities dimly shadowed forth in history; mighty ruins in the midst of deserts, defying by their very desolation and lack of definite form the description of the traveller; the remnants of mighty races still roving over the land; the fulfilling and fulfilment of prophecies; the plains to which the Jew and the Gentile alike look as the cradle of their race. For six centuries Nineveh was one of the great cities of the

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[*] Since this was written I have seen a letter by A. B. Powell in the London Free Press which tells of another last survivor of Waterloo—William Chambers of Dresden, in the county of Kent—who not only fought at Waterloo but went through the whole of the Peninsular war. Mr. Powell says that Mr. Chambers was born in the county of Antrim, Ireland, on the 12th of September, 1787. and is therefore in the 105th year of his age. "He can carry on a conversation with much strength and intelligence, and gives a most vivid description of his life in the army." He came to Canada in 1831. Dr. Samson of Blenheim also writes to me concerning him: "The old man Chambers has been an intimate friend of my father for sixty years, and no doubt stands alone today as the most remarkable man of his age in the world. He spent a day with me last week and seems as bright and clear as ever in referring to many of the incidents of his life. His description of the times of the Irish Rebellion of '97 seemed like a chapter from ancient history. To have seen George the Third on his throne for thirty-three years and all of the events that have occurred since is certainly to have seen an immense part of the history of all mankind. A master of elegant English, an ardent reader, and something of a philosopher for nearly a century, it was a treat to spend a day with him. He said to me the other day that he had recently sent an invitation to a widow whom he had heard of in her hundredth year to accept his escort to the Exposition next year!"

East, or perhaps it might more accurately be described as a group of cities. It was the capital of a great empire, in which a series of palaces surrounded by great and high walls had been built by successive kings. It was a city of three days' journey according to the prophet Jonah, or of sixty miles circumference according to the old geographer Diodorus; and it had a population computed to be not less than 600,000. Nineveh perished with the last Assyrian king 2,500 years ago, and from that time until the explorations of Botta and Layard were commenced fifty years ago its place on the world's map was blotted out. Having been abandoned by man, its palaces and walls were gradually buried under the fine yellow dust which in the course of centuries the winds had drifted over them. Xenophon, who commanded the Retreat of the Ten Thousand, encamped upon the site of the city without knowing its name. When the battle between the Romans and the Persians was fought within sight of the mounds in the seventh century of our era "the city and even the ruins of the city had long since disappeared," as we are told by Gibbon. And about a hundred and twenty-five years ago the traveler Niebuhr, father of the historian, passed over Nineveh without perceiving it; he mistook for a ridge of hills the dust-covered rampart of brick and earth.*

Then there is Troy, the old Troy of your Homer if you read old Homer here. That city was taken and burnt by the Greeks more than 3,000 years ago, and its place on the map has been a subject of contention with scholars down to a period of less than ten years ago. "The question is now decided for ever," Dr. Schuchhardt tells us. "On the hill of Hissarlik Dr. Schliemann has uncovered the ancient palaces of Troy, has laid bare its colossal fortifications, and brought to light its treasures of gold and silver. Moreover, in the country round about, his unwearying exertions have proved the accuracy of many details, which show a coincidence, astonishing even to the most credulous, between the picture unfolded in Homer and the one preserved to this day."* The mound of Hissarlik is shown by Dr. Schliemann to be the remains of seven successive cities, one built over the ruins of another, and the second of which was the Troy of Homer. The first lies on the virgin rock, 115 feet above the sea, while the full height of the hill at the beginning of the excavations was 162 feet. The second is separated from the first by a layer of debris eight feet in thickness, covered by a layer of soil nearly two feet in depth, which proves that the site had been deserted and not built upon for a long time. The walls, the towers, the palace, the pottery, and the gold and silver cups and bowls and vases and ornaments uncovered in the second city are remarkable evidences of its strength and civilization, and fully justify the observation of Dr. Schliemann in his last report that only after he had cleared the walls and excavated beneath them was he able to clearly understand how long the duration of this settlement had been and for what centuries its golden era must have lasted. He was able to verify in many particulars the accounts of Troy given by Homer, as traced in the records of the ruins, not the least important of which is the fact so curtly told in our primers that "Troy—was—burnt," the proof of which he found in the charred beams and the vitrified brick of its walls. And he was able also to establish this further fact, to quote Schuchhardt again, that "there existed on the site of Hissarlik, at a period far anterior to any we know of on Greek soil, a proud and royal city, mistress of sea and land; and the singers of the Trojan war, just as they were familiar with Ida and Skamander, with the Hellespont and the Isle of Tenedos, knew also of this city, knew of its golden age and of its mighty downfall."†

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*The following account of ancient Babylon is taken from a paper by Prof. Hermann v. Hilprecht of the University of Pennsylvania in the Sunday School Times of May 14, 1892:

"Between the Euphrates and the Tigris—where the drama of the childhood of man was enacted, where the waves of the flood roared, and where the unity of the race of man found an early grave in shrill discord—we behold also the seat of the most ancient empire. And in Ur of the Chaldees the world's history takes a new beginning,—not built on the might of an Asiatic despotism, but firmly established upon the living faith of that man who forsook his country and kindred in order to serve the God of gods in a distant land.

"Some two thousand years before Abraham made his famous journey there existed on the banks of the Euphrates, farther to the north, a primeval sacred spot,—ancient Babylon. This was centuries before Ur came into prominence as the city of the moon-god cult, and, as the seat of mighty dynasties, made its influence felt in the history of Babylonia. About a two days' journey to the southwest of the present Bagdad lay the city, situated on a veritable lowland cut up by thousands of smaller and larger canals. It was in its commanding and central position, which later engaged the attention of Alexander the Great, that the unique and long-recognised significance of the city more particularly lay. The ample watering of the rich alluvial ground, especially in the neighborhood of the Euphrates and Tigris, under the ingenious schemes for irrigation invented by the inhabitants, produced a marvelous vegetation unequalled in the whole world. As late as B. C. 500 the fields of the comparatively little country of Babylonia brought unto king Darius a tribute of grain equivalent in amount to one-third of the entire produce of the broad domains of Persia. Then the country was 'an inexhaustible storehouse, and abounding at the same time in palm-groves even unto the borders of the sea.' To this fact testify the thousands of the cuneiform tablets in museums in London, Paris and Philadelphia. . . .

"To-day there is little left of the proverbial glory of this early seat of civilization. Palm-groves of extraordinary beauty indeed still line the sluggish waters of the Euphrates; but otherwise the neighborhood of Babylon is an arid, burning wilderness. The ancient canals which traversed the whole region and dispensed fertility have dried up, and the winds of winter have often buried them under the drifting sands And in striking harmony with the Persian caravans of the dead, whose mouldering and offensive corpses every year infest the routes from Bagdad to Kerbela and Meshed Ali, the far-stretching ruin heaps of ancient Babylon, as watchers of the grave, tender to them a heart-sore welcome. For several miles the city of the dead stretches along both banks of the river, with its ruins of walls and terraces and the shattered homes of its former inhabitants. At the northeastern point encompassed still by deep trenches and massive brick walls, as of a prison, there rise upon the massive substructure the ruins of Nebuchadrezzar's palace, with its spacious chambers and its now empty halls.

"Far away in the southwest, still to the height of a hundred and eighty feet toward the brazen heavens, rise the vitrified ruins which some scholars believe to be the remains of the 'Tower of Babel.' When I had climbed laboriously to the highest point of this monument of human ambition I leaned for a moment against the walls of the old tower, which have stood for millenniums, and my eye glanced longingly beyond the sand-flats and morasses of the Babylon of today, to seek the life which filled the streets of the Babylon that was. But where once the temples of Bel and Nebo shone like the sun, and, sparkling like jewels, attracted throngs of worshippers to make their offerings; where once the hanging gardens of a Semiramis delighted the eye as a world's wonder; where once the Median princess Amytis, walking to take the air in the shadow of rare trees and fragrant shrubs, dreamed of the mountain ranges and leafy woods of her home, —there rises now a chaotic mass, broken by heights and hollows, from the lonely plains of Babylon. Turn whithersoever we may, our glance is everywhere met with scattered fragments of the storied piles, with the high-sounding inscription, 'Nebuchadrezzar, king of Babylon, adorner of the temples Esagila and Ezida, first-born son of Nabopolasser, king of Babylon, am I.' The proud speech of the self-conscious monarch, before whose scepter the peoples of Asia as far as the Nile stream bowed, sounds like a hollow mockery in the face of Isaiah's grewsome words, 'How art thou fallen from heaven, O day star, son of the morning! how art thou cut down to the ground, which didst lay low the nations!' If I ever had doubted the exact fulfilment of Old Testament prophecy such a doubt must have vanished under the impression I received from these striking facts among those cheerless solitudes full of ruins and graves, full of death and decay."

I have said this much by way of preface in the hope of giving you some idea of the lapse of time as we find it in the annals of human events. What it means when we come to consider the history of the earth itself, how we measure the time of geologic events, we can hardly conceive, much less determine. The brick in the walls of this building was made out of the brown clay of the Drift age, the Saugeen clay of the geologists, which you find extending over a wide area of the province, underlying the humus or vegetable mould and perhaps a few feet of gravel or sand. It is as old as the glacial era, or the closing period of that era, and doubtless older than our great lakes as these now exist, and very much older than our forests. But after all it is only the product of older rocks, of the granites and clay slates of the Huronian and Laurentian areas, ground to dust by glaciers, or decomposed by the action of water and weather, or dissolved by carbonic acid in a moist atmosphere. Much older is the lime in the plaster of the walls, the material of which we get at the nearest point from the Niagara group of rocks, whose aggregate thickness in places is not less than 150 feet. Whether built up by the encrinites whose forms are so plentiful in the upper beds, or by the deposition of calcareous matter chemically separated from the primary rocks in the ancient seas, or, as seems most likely, by both these agencies working together, the process must have occupied thousands of years. Still more ancient is the brown sandstone used in the foundation of your building, taken from the upper beds of the Medina formation, near the base of the Niagara escarpment. Where this stone is quarried at the Forks of the Credit the Niagara limestones overlie it to a height of nearly 200 feet; and this sandstone, like the limestone and the clay, is material reworked from the primaries. Very much older than the clay or lime or sandstone are the slates on the roof. The slates we use here are obtained for the most part from the province of Quebec or the state of Vermont, where they occur in the so-called Quebec group of rocks in the Lower Silurian system, but which is probably of pre-Cambrian or Huronian age. We know that the best slates are found among ancient lavas and rocks which have been faulted and tilted, and we have reason to believe that they have been formed under the influence of great

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*Schliemann's Excavations, an Archæological and Historical Study, by Dr. C. Schuchhardt, p. 18.
†*Ib.* p. 92.

pressure and heat. In this province if slates of good quality and cleavage exist at all they will no doubt be found in the Archæan formations of the north, and explorers report their discovery there. On Temagami lake and the Matabechawan river there is said to be enough to supply the continent,—but the stories of explorers must be received with a grain of salt.*

But if the sandstones, limestones and clays out of which the walls of this college building have been constructed are old, what is to be thought of the age of those primary rocks out of whose ruins they were brought, and worked over grain by grain, and slowly laid down again by the waters of the sea in new beds removed by hundreds of miles in distance and by eons of years in time from the parent bodies? And what is the life of man compared with those primary rocks, or those still order and formless rocks whence the primaries had their origin? To think on those themes or seek to answer those queries is only to bring up afresh the questioning which came to Job out of the storm.

Who is this that darkeneth counsel
By words without knowledge?
Gird up now thy loins like a man;
For I will demand of thee, and declare thou unto me.
Where wast thou when I laid the foundations of the earth?
Declare, if thou hast understanding.
Who determined the measures thereof, if thou knowest?
Or who stretched the line upon it?
Whereupon were the foundations thereof fastened?
Or who laid the corner stone thereof;
When the morning stars sang together,
And all the sons of God shouted for joy?
Or who shut up the sea with doors,
When it brake forth, as if it had issued out of the womb;
When I made the cloud the garment thereof,
And thick darkness a swaddling band for it,
And prescribed for it my decree,
And set bars and doors,
And said, Hitherto shalt thou come, but no further;
And here shall thy proud waves be stayed?

We are appalled by the story of our earth's creation; yet it is befitting that we study it, and speculate upon it, and strive to understand it. Even in things too large for finite comprehension it is profitable to speculate and enquire if we do so in a spirit of reverence and of loyalty to truth, for the mind expands by the contemplation of the universe about us.—But let us get on to the practicable and the knowable.

The primary rocks, embracing the Cambrian, Huronian and Laurentian systems, together with the igneous rocks which sometimes overflow them as trap, but are oftener extruded through them as veins and dykes, are the source of almost all our minerals. Of the primary rocks we know something. They make up the surface of a very large portion of our country, and small regions of them have been explored and studied with more or less care for many years. They are indeed of vast extent and volume, covering an area in Ontario alone of not less than 150,000 square miles. In the Dominion they reach from the straits of Belle Isle on the Atlantic to Demarcation point on the Arctic ocean, and cover an area of 2,000,000 square miles. Their thickness has never been measured, and owing to foldings and tiltings it may be impossible to measure it, but one section of the Laurentian series north of the Ottawa river was computed by Logan to be 32,750 feet or a little over six miles. By others the depth of the upper division of this formation is estimated at 100,000 feet or nearly twenty miles. The Laurentian mountains, which extend in a V-shaped line from Labrador to the region west of Hudson bay, are the oldest in America; and upon both their northern and southern slopes in Ontario, but especially upon the latter, are stratified beds of successive ages which are no doubt the accumulations of sand and mud worn away by the action of ice and rains upon the mountain ranges during countless time.

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*This reminds me that after the Mining Commission had taken the evidence of Sir James Grant at Ottawa the witness volunteered a piece of wholesome advice. "You must be very careful, Mr. B.," Sir James said in his deliberate Scotch way, "of what these mining men tell you; they are so prone to exaggerate." "Yes," I said, "I have no doubt David had them in his mind's eye when he made that hasty remark. You know David prepared a hundred thousand talents of gold, and a thousand thousand talents of silver, and brass and iron without weight for the building of the temple; and when he said in his haste that all men are liars I sometimes suspect that he had before him his experience with the mining men of his day." Sir James thought so too.

"The destruction of the elevations in the Laurentian district," Prof. Shaler says, "is so complete that we cannot make out the original trend of the several ranges; as in an ancient city where the devastation wrought by time leaves nothing but a confused ruin which we only know to have been the dwelling-place of men by the nature of the materials, so this old mountain field can only be shown to have been at one period like the newer systems of the Cordilleras and the Appalachians, by the waste of its former structures."*

If you examine a fragment of Laurentian rock under a glass or even with the naked eye you will observe that as a rule it does not consist of one mineral or element, but of a variety of metallic and non-metallic substances which enter into almost endless combinations. Of the sixty or more minerals found in this Laurentian series and its enclosing veins there are twenty-three enumerated by Sterry Hunt which are constituents of the country rock as well as of the veins, including such important ores as apatite, serpentine, muscovite, quartz, magnetite, hematite, pyrite and graphite. Great limestone beds are interstratified with gneisses and quartzites in the formation, and disseminated through the limestone or arranged in parallel bands in it are grains of specular and magnetic oxides of iron, scales of mica and graphite, and crystals of iron pyrites and apatite, all of which are sometimes met with also in large accumulations either in veins or running with the stratification.†

In the Huronian and Cambrian systems the minerals are largely the same as in the Laurentian, from which they have been derived; but they also abound in dykes and are covered in places with extensive overflows of greenstone and basaltic trap, and are reticulated with mineral veins. They are pre-eminently the metal-carrying rocks of our province, and are for that reason of first importance from an economic point of view, or are by most persons so regarded. The Cambrian system is confined chiefly to the shores of lake Superior, embracing the Animikie, Nipigon and Potsdam formations; but there is also an outcropping of the Potsdam in the eastern part of the province, from the river St. Lawrence below Brockville to the town of Perth in Lanark. The Huronian is much more extensive, consisting of a number of belts or areas from the upper waters of the Ottawa river to Lake of the Woods. The system has not yet been accurately mapped, but the largest belt is no doubt that which extends from Georgian bay northeastward to the province line at lake Temiscaming, where it enters Quebec and continues to lake Mistassini. Other important belts lie between lake Superior and the western limit of the province, and these like the one north of Georgian bay have their greatest length in northeast and southwest lines. The most extensive remaining areas are those in the upper basin of the Moose river and its tributaries, and in the region north of lake Superior and east of lake Nipigon. The mineral-bearing district of which the northern part of the county of Hastings is the centre was at one time supposed to belong to the Laurentian system; but its rocks are now by some geologists classed with the Huronian, and by others with a later series, the Taconian.

Rocks of the Silurian and Devonian systems, which constitute all the more recent formations in Ontario, have hardly been disturbed at all since their first deposition, except as changes of elevation or subsidence may have occurred slowly and uniformly over wide areas. Veins carrying small quantities of galena, copper and some other metals cut through the lowest Silurian formations in the eastern parts of the province, where thin beds overlie the Laurentian rocks; but no dyke or vein has yet been discovered in the sandstones, shales and limestones which cover to great depths the country between the great lakes. Mineral veins are most frequent in districts where eruptive rocks are abundant and are confined to certain areas of disturbance, and of these conditions the Silurian and Devonian rocks of western Ontario give no sign. Either they were laid down in a quiet period of the earth's history, or the region over which they extend was never seriously subject to the influence of disturbing agencies. It is a vast plain whose level is only broken by long and low anticlinals, and therefore there have been no great movements to divert pressure from one part of the earth's crust to another, to find out lines of weakness and develop volcanic excitement along lines of fracture.

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* The Story of our Continent, p. 99.

† Prof. Coleman of the School of Practical Science informs me that he has observed the following minerals in our Archæan rocks in considerable amount, viz.: Essential and Secondary—Quartz, orthoclase, microcline, plagioclase (several species), muscovite, biotite, hornblende (several species), augite (several species), epidote, serpentine, calcite, eleolite, olivine, kaolin and dolomite. Accessory—Garnet (several species), tourmaline, zircon, apatite, magnetite, ilmenite, titanite, rutile, hematite, limonite, siderite, pyrite, pyrrhotite, chalcopyrite and graphite. Several other minerals he has observed in less amount.

I would not however have you assume that there are no minerals where there are no veins. Iron ore is sometimes found in large deposits in regions where no veins occur; and although it has not yet been discovered in the Silurian or Devonian systems of western Ontario, except as the local coloring matter of certain strata, no one can definitely say it does not exist there. Salt is found in great abundance in beds of the Onondaga formation, and above it in parts of the same formation are extensive beds of gypsum. Of limestones, sandstones and clays there are illimitable quantities, suitable for economic uses; and of all the minerals of those newer systems, salt, petroleum and natural gas excepted, the source is to be sought in the Archæan rocks of the north.

As far as known there are about 600 mineral substances in the crust of the earth which are made up of the 64 or more elements found in the earth and its atmosphere. These elements are classed as gases, metals of the alkalies, metals of the earths, metals proper and non-metallic substances; but many of them must be exceedingly rare, since it is estimated that eleven of the number make up 99 per cent. of the earth's crust. One of the gases, oxygen, forms one-half of the whole; silicon, a non-metallic substance, one-quarter; aluminium, a metal of the earths, one-tenth; calcium and magnesium, two other metals of the earths, 8 per cent. of the whole; sodium and potassium, metals of the alkalies, 3.6 per cent.; carbon, iron, sulphur and chlorine together, 2.4 per cent.; and all other bodies one per cent. Of the compound bodies silica constitutes 53 per cent. of the whole; alumina 19 per cent; and lime, magnesia, soda and potash, 17 per cent; leaving the combinations of oxygen with carbon, iron, sulphur and chlorine to make up 7.5 per cent., and with other bodies 3.5 per cent. It thus appears that the metals proper constitute only a very small part of what we know as minerals; and in no corner of the globe are they so generally diffused as to form any great bulk of it, although some areas are vastly richer in the metallic ores than others.

No one can undertake to give an exhaustive account of the minerals of our province, for the sufficient reason that only a small portion of it has been explored. Fifty years ago the work of the Geological Survey was begun by Sir William Logan, with a small staff; but the labors of the Survey were spread over the whole of Upper and Lower Canada. Twenty-five years later the area was extended by Confederation to the maritime provinces, and in five years more the country was taken in from ocean to ocean, embracing a land area of 3,315,000 square miles. Logan's survey of Ontario did not extend northward beyond the height of land, and indeed a very large part of the Ontario of our day northward and westward was not supposed to lie within its boundaries a quarter of a century ago. Since then other portions of the Dominion have demanded the attention of the Survey, and the result is that little has been added to our geological knowledge of Ontario since the publication of Logan's Geology of Canada in 1863. Small sections have been surveyed with more or less care. Hunt made a report on the Huron salt district, Vennor on the Hastings district, Lawson on the Lake of the Woods, Ingall on the silver-bearing rocks of lake Superior, and Bell on the Sudbury district. Other larger territories have been explored in a general way, but not so as to supply very definite or practical information on the character of their ores or minerals. Bell's report on the Hudson bay district will answer for illustration; an exhaustive report on so extensive a region could not be made on the observations of two short seasons of field work. His more recent report on the geology of the Sudbury mining district is based on the labors of three seasons, and embraces a tract 72 miles long by 48 broad, or 3,456 square miles. Now at 130 working days in the season a thorough survey would require the covering of nine square miles per day, which is far more than could be accomplished under the most favorable circumstances. But see what the difficulties were as described in the report.

Rocky ridges and boulder-covered slopes, alternating with swamps and small lakes, are the rule over the greater part of the area. In most parts the boulders are not only thickly scattered over the uneven rocky surface, but are often piled on top of one another without any finer materials between them. The trees which originally grew between and even on top of the boulders have generally been killed by forest fires, and their trunks have fallen over them in every direction. A second-growth thicket of small prickly spruces entangled with tough young birches has sprung up among the boulders and resists the explorer's progress like a continuous hedge. This, together with the uncertain footing, due to the boulders and the net-work of prostrate trunks, renders it very difficult to make one's way through these obstructions. Indeed it sometimes became impossible to do so until we had first chopped a passage through them.*

With such hindrances to exploration large portions of the field must have escaped notice, and so the report cannot be assumed to deal fully with the ores and minerals of the district. It is possible that there are many metalliferous veins and ranges in those two and a quarter millions of acres of his sheet which the geologist either passed over unobserved or did not cross at all. The late Alexander Murray spent a year in surveying the district between lake Wahnapitae and the mouth of Whitefish river on lake Huron, yet only the barest mention is made in his report of a sign of the nickel ore which within the last six years has made the name of Sudbury famous in America and Europe. Not one-tenth part of the province has been explored, we are told by the head of the Geological Survey, although the work has been carried on by the government for fifty years. Therefore we are forced to speak in a qualified way on the extent and value of its mineral resources. We know that they are considerable by the number and variety of discoveries which have been made and proven. They may be vastly greater, but that can be determined only when the whole area has been gone over, and 200,000 square miles is a very large territory to be scanned by the geologist's eye or sampled by his hammer. Fortunately his labours are being supplemented by the explorer, and in recent years the explorer has developed not a few of the qualities of an expert. Accordingly I feel sanguine that the ratio of progress in knowledge of the geology of our province will soon be increased, and that we shall not have to wait five hundred years for a completion of the survey.

I propose now to pass in review, as concisely as may be, some of the principal ores and minerals of the province, their places of occurrence, and the extent to which these resources of our natural wealth have been developed; and for convenience I shall group them under the following heads, viz: I. Metals and their Ores; II. Structural and Decorative Materials; III. Mineral Pigments; IV. Mineral Fertilizers; V. Refractory Materials; VI. Salt and Mineral Waters; and VII. Materials of Light and Heat.

I. Of the principal metals we have, in alphabetical order, aluminium, arsenic, copper, gold, iron, lead, nickel, silver and zinc, one or two of which are sometimes found in the native or metallic state, but all of them in chemical combination with other elements in the form of ores and earths. Often they occur in veins traversing the crystalline rocks and in the rocks themselves, frequently as deposits and impregnated beds, and sometimes, but very rarely, in alluvial clays, sands or gravels. How the metals came to occupy veins or the country rock, and whether they came as elements or compounds, no one can tell. We can speculate on their source, and there are many theories,—so many, in fact, as to suggest the story of the young candidate at a civil service examination. "How did you succeed my son?" his father asked. "O pretty well, father, I guess. I answered one question, I am sure." "And what was that?" "Well, they asked Why Charles I. was put to death? and I answered that I didn't know." As to the metalliferous veins there are theories of contemporaneous formation, of igneous injection, of electric currents, of aqueous deposition from above, of sublimation, of lateral secretion and of ascension. Prestwich says that by Werner and his school "They were supposed to have been introduced in a state of solution from above; by others they were supposed to have been injected simultaneously with the opening of the fissures from below; but the more general opinion of geologists now is that they are the deposits formed during lengthened periods by thermal mineral waters or by sublimation." And again he observes that

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*Report on the Sudbury Mining District by Dr. Robert Bell, p. 7 F.

> Ordinary mineral veins were no doubt fissures in which there were cavities or spaces left open for a length of time, and in the interstices or on the sides of which were gradually deposited a variety of minerals and of metallic ores. The banded structure of some veins, and the fact that the minerals are such that could be deposited in water, tend to prove that their formation has been in most cases due to thermal waters, rather than to sublimations of gases and vapors such as are now discharged in the solfataras of volcanic districts. It is possible that in some instances such emanations may have contributed to a particular result, but in the majority of cases the phenomena agree better with the hypothesis of aqueous solution.*

Sir Archibald Geikie in discussing the various theories of origin says:

> The structure and characteristic mineral combinations of metalliferous veins are precisely such as would be produced by deposition from aqueous solution. There can hardly be now any doubt that the contents of these veins have generally been deposited by water. But the source from which the metals were derived is not so obvious. The fact that the nature and amount of the minerals, and especially of the ores, in a vein so often vary with the nature of the surrounding rocks shows that these rocks have had an influence on the precipitation of mineral matter in the fissures passing through them, if they were not themselves the source from which the metals were obtained; for, as already remarked, the presence of the heavy metals has now been detected in rocks of almost every kind and age. On the other hand, in some volcanic districts at the present time various minerals, including silica, both crystalline and chalcedonic, metallic sulphides, and even metallic gold, are being deposited in fissures up which hot water rises. Each of these modes of origin may in different cases have occurred. It is almost certain, from what we now know of the diffusion of metallic substances, that there must be a decomposition of the rocks on either side of a fissure, perhaps to a great distance, and that a portion of the mineral matter abstracted will be laid down in another form along the fissure walls. If, on the other hand, the rocks on either side of the fissure are permeated for some distance by hot ascending waters, holding such metalliferous solutions as have been detected in the hot springs of California and Nevada, some of the dissolved mineral substances will doubtless be deposited in the fissure, and may even be introduced into the pores and cavities of the adjacent rocks.†

Sterry Hunt's theory is set forth as follows:

> The metals.. seem to have been originally brought to the surface in watery solutions, from which we conceive them to have been separated by the reducing agency of organic matters in the form of sulphurets or in the native state, and mingled with the contemporaneous sediments, where they occur in beds, in disseminated grains forming fahlbands, or are the cementing material of conglomerates. During the subsequent metamorphism of the strata these metallic matters being taken into solution by alkaline carbonates or sulphurets, have been redeposited in fissures in the metalliferous strata, forming veins, or, ascending to higher beds, have given rise to metalliferous veins in strata not themselves metalliferous. Such we conceive to be, in a few words, the theory of metallic deposits; they belong to a period when the primal sediments were yet impregnated with metallic compounds which were soluble in the permeating waters. The metals of the sedimentary rocks are now however for the greater part in the form of insoluble sulphurets, so that we have only traces of them in a few mineral springs, which serve to show the agencies once at work in the sediments and waters of the earth's crust.‡

And Arthur Phillips, after demonstrating the almost universal presence of heavy metals in rocks belonging to every geological period, states his conclusions briefly in these words:

> There can be no longer any doubt that the filling of veins has often been derived, in a state of chemical solution, from the surrounding country rock, and the theory of lateral secretion appears to explain more satisfactorily than any other certain phenomena not otherwise easily understood. It moreover not only accounts in a satisfactory way for the changes which take place in metalliferous veins when passing from one formation into another, but it also affords a reasonable explanation for the fact that shoots of ore usually follow the dip of the enclosing rocks.§

This relation of ore bodies to surrounding rock was illustrated in the Silver Islet mine, to which I shall again refer, and has long been familiar to miners. The famous

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* Geology, Chemical, Physical and Stratigraphical, by Prof. Joseph Prestwich, vol. I pp. 334-5.

† Text Book of Geology, p. 590.

‡ Chemical and Geological Essays, 3rd ed., p. 220.

§ A Treatise on Ore Deposits, p. 85.

Dolcoath mine in Cornwall changed from copper to tin some forty years ago, and in both Cornwall and Devon it has been observed that some lodes yield tin where they cross granite, and copper where they traverse slate, changing from one metal to the other as they cross from the one rock into the other. In the north of England, again, the galena is most abundant in the limestones and scarcest in the shales, and Geikie mentions the fact that the veins in the Great Limestone, as it is called, which is 150 feet thick or less, have yielded as much lead as all the rest of a mass of 2,000 feet of strata put together.

The question of the origin of metals as found in veins and in the country rock has not been solved, but I thought it might interest you to be told what theories are held respecting it, as well as some peculiarities concerning the occurrence of metals and their ores.

As to aluminium, the first of my list, the theory of its origin is not a matter of so much doubt as that of most other metals. Yet it is never found in a free state in nature, and although by great odds the most abundant of all the metals—being estimated to make up a tenth of the earth's crust—it is one of the most modern in respect of discovery. A great French chemist, Lavoisier, suspected its existence about a century ago as the metallic base of alumina, but not until 1827 was it isolated for the first time. Then however it was obtained only as a metallic powder; the first ingot was cast in 1854. Alumina itself was not named until 1760, when it was obtained by calcining alum. We find it in many forms and combinations. It is the basis of all clays, and when crystallized in six-sided prisms it is called corundum, the clear and blue varieties of which constitute sapphire and the red varieties oriental ruby. Alumina is one of the chief components of felspar, which is a mineral generally of igneous origin, erupted from below the sedimentary strata. Felspar itself is one of the components of granite and syenite; but occasionally it is found separate and in large masses, as in parts of the counties of Frontenac, Leeds and Lanark. It is very generally diffused in rocks of the Laurentian system. Exposed to atmospheric influences the soda and potash felspars are altered to kaolin or china clay, but generally the admixture of lime, iron and other impurities on this side of the Laurentians has produced the common clays of our farmland. In localities on the other side of the Laurentians, especially on the Missinaibi and Abittibi rivers on the Hudson bay slope, there are extensive deposits of a very pure kaolin which, when reached by railway communication, will prove to possess great economic value. Doubtless you sometimes wonder at the lightness and strength of porcelain or chinaware, but wonder will cease when you know that it is made up largely of the metal aluminium. The sample of this metal before me, which is 8 inches long, 4⅝ inches wide, one inch in thickness and weighs only 3 pounds 8½ ounces, was smelted from a charge of kaolin in a crucible. As made by the first process thirty-eight years ago, aluminium cost its weight in gold. Six years later it was produced at a cost of $8 per pound and the selling price was $12, at which price it remained for twenty-five years. In 1885, by the application of electricity, the cost of production was reduced to $1 per pound; and by an improvement of the electrolytic preparation the cost in the following year was further reduced to fifty cents per pound, the selling price now being seventy-five to ninety cents per pound. By this last process it is claimed by Prof. Richards, instructor in metallurgy at Lehigh University, that "the electrolytic preparation of aluminium has reached its climax of simplicity." In an article in the January number of the Cosmopolitan Magazine Prof. Richards says:

> The electrolytic processes for pure aluminium will be developed, but not radically changed. Details will be improved, but in principle they have reached their maximum development. It is unlikely that by them aluminium will ever be made and sold at a fair profit much below its present selling price. It will be several years before this maximum development is reached, and then the aluminium industry, metallurgically speaking, will again be at a standstill. The next upheaval after this will be the discovery of a process using neither sodium nor electricity, a purely metallurgical one, simple, rapid and cheap, by which aluminium can be produced at a cost of five to ten cents a pound. The writer hardly looks for this within the next fifty years, but before the next century has run its length such a process will be in operation.*

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* The Cosmopolitan Monthly Magazine, January, 1892, p. 28.

Well, the truth of an old adage finds here another illustration : It is never safe to prophesy unless you know. A purely metallurgical process has already been discovered, a sample of what it can accomplish is the block of aluminium before me, and I am assured that at a selling price of twenty-five cents per pound there is a fortune in it for the inventor and the producers. As to its uses in the arts, these will depend on its qualities. It is light, being only 2.6 times heavier than water, while iron and steel are 7.8 and gold 19.3 times heavier than water respectively. A cubic foot of aluminium weighs 168 lb., while a cubic foot of iron or steel weighs 487 lb. and of gold 1,206 lb. It is strong, the tensile strength per square inch being 26,800 lb., while that of cast iron is 16,500 lb., of wrought iron 50,000 lb. and of steel 78,000 lb. It is feebly magnetic, it has no sensible taste or odor, it may be forged or rolled like gold or silver, it is ductile, it is fusible, and it is almost non-corrodible, neither air nor water nor sulphureted hydrogen nor sulphuric acid having an appreciable effect upon it; besides which it has most valuable properties as an alloy with other metals. In his excellent work on Aluminium, published two years ago, Prof. Richards says :

> Whatever its price, it can only replace gold or platinum because of its lightness ; it already replaces silver especially because of its resistance to sulphur, as well as for its lightness, besides being cheaper ; it can only replace the common metals, at its present price, for uses where its lightness is an extraordinary advantage. But when its price is down to that of these baser metals it will begin to replace them by virtue of its other superior qualities, chemical and physical ; aside from its lightness it will win a large field simply in comparison with them on its merits as a metal. Thus there are wide applications now almost unthought of, because the high price has been a blank wall to stop its use, but as it cheapens more and more we hear every day of new uses brought to light. Thus its sphere will widen until, since its ores are as cheap as those of iron, it will approximate in utility to that universal metal. . . When aluminium becomes cheaper it will without doubt be used for culinary articles of many kinds, replacing copper and tin vessels, for it is attacked to a less degree by the acids and salts ordinarily found in food than either of those metals, and possesses the great superiority that if dissolved its salts are not poisonous like those of copper or tin, being, on the contrary, perfectly harmless. The sulphurous acid of the air or of the products of combustion likewise leave aluminium untouched, while they quickly blacken silver.*

And in the article in the Cosmopolitan from which I have already quoted the same authority says :

> It has been discovered that many of the alloys of aluminium with other metals have very remarkable properties. For instance, five or ten per cent. of aluminium added to copper forms a beautiful bronze of a golden color and as strong as ordinary steel. A small portion of copper or titanium added to aluminium makes it much stronger without increasing its weight perceptibly. It is these alloys which may replace steel for many engineering purposes, for they approach steel in strength and yet are very little heavier than aluminium. Again, a very small amount of aluminium has a decidedly beneficial effect on cast iron, so that many founderies are using it, while for the difficult process of making steel castings aluminium is coming to be regarded as almost a necessity. Hundreds of pounds are being used weekly for this purpose.†

I have said so much on aluminium that I must necessarily be very brief in referring to other metals and their ores ; but I have done so (1) because this metal is less known than most of the others, (2) because it is a metal of great promise, and (3) because it appears likely that no other part of America is so rich in the ores or earths from which aluminium may be extracted as our own province.

Arsenic is not a metal of high commercial value, it is not consumed in large quantities, and our supply of it in Ontario in the form of the white oxide far exceeds the call of the market. It is one of the components of the mispickel ores in the county of Hastings, and I believe that a sufficient quantity was produced at the Deloro gold reduction works when these were in operation several years ago to meet all requirements to the present time.

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* Aluminium : its History, Occurrence, Properties, etc., by Joseph W. Richards, M. A., 2nd edition, pp. 367-9.

† The Cosmopolitan Monthly Magazine, January, 1892, p. 286. The statement that these alloys are very little heavier than aluminium can hardly be correct, except in cases where the latter metal constitutes the principal part of the alloy.

Copper is found in various localities, on the north shore of lake Huron, on the east shore of lake Superior and elsewhere, generally as copper pyrites in quartz veins traversing greenstone or diorite, as at the Bruce and Wellington mines; but sometimes native and in sulphurets, in amygdaloidal trap, conglomerate and sandstone, as at Mamainse peninsula and Michipicoten island in lake Superior, and at points on the mainland along the north shore of this lake. It may be noticed here, and the fact has an important bearing, that microscopic observations made by the late Prof. Irving of the United States Geological Survey have established a complete identity between the Michipicoten island rocks and those of the typical copper-bearing districts of the south shore of lake Superior in which are situated some of the largest and richest copper mines in the world.* Copper ore is found in many other parts of the province besides those already mentioned, but perhaps in the greatest quantity in association with nickel in the Sudbury district. For thirty years, ending with 1875, copper mining on a large scale was carried on at the Bruce mines; and Mr. William Plummer, who had charge of the works for a number of years, has estimated the value of the product of these mines at between $6,000,000 and $7,000,000. Operations at these mines were discontinued owing to the low price of copper and have not since been resumed.

The ore of lead, galena, usually carries a small percentage of silver. It occurs in veins, the greater number if not all of which in this province are found in rocks of the Huronian and Cambrian systems. Mines have been opened in the counties of Lanark, Frontenac and Peterborough, and smelting works have been erected at Kingston and near Carleton Place, but owing to wasteful management in one case and to a limited supply of ore in the other these enterprises failed. There are rich veins near Garden river, in the district of Algoma, which were worked about ten years ago; and although considerable quantities of ore were raised, stamped and shipped, the lack of capital and markets led to the works being closed at the end of three or four years. On the north shore of lake Superior, near Black bay, a number of veins have been discovered, as also in the district of Nipissing, near lake Temagami.

We have gold-bearing ores in many localities, as in the Hastings region, in the Sudbury country, in the valleys of the Thessalon and Mississaga rivers north of lake Huron, on the north shore of lake Superior, near Lac-des-milles-lacs, and on the islands and mainland of Lake of the Woods. Gold occurs almost always in quartz veins, in rocks of Huronian age; but sometimes it is said to be found in bands of slate, as on a location near the Vermilion river, west of Sudbury. Gold mining in Ontario has never been a profitable business, although fine specimens showing free gold are often exhibited by prospectors and real estate miners; but locations now being worked on Lake of the Woods, in the county of Hastings and in the Sudbury district are claimed to be full of promise Reduction works recently started in the two regions first named are likely to prove the value of the ores, which as a rule are hard to treat. As illustrating the deceptive qualities of veins supposed to be gold-bearing, I may mention that of 96 specimens examined by the chemist of the Geological Survey, particulars of which are given in the last report of the Survey, 46 contained neither gold nor silver, 13 showed traces of gold and 4 of silver, while of the remaining 33 there were 21 which contained gold and 18 silver, some specimens showing both metals. Yet of those 96 specimens 73 were collected by officers of the Survey, thus proving the truth of a saying common among miners that "A great many other things are mistaken for gold, but gold is never mistaken for anything else."

Ores of iron are abundant in the Laurentian and Huronian formations, chiefly as magnetite, but sometimes also as hematite and limonite. In the eastern part of the province there are large bodies of magnetic ores in the counties of Peterborough, Hastings, Frontenac and Lanark, some of which are of excellent quality; but sulphur is often present, and occasionally titanium, both of which are very objectionable substances in combination with iron. Yet it seems likely that methods will be found to get rid of both sulphur and titanium, or to greatly reduce their proportions in the ore, in which direction very marked progress has recently been made by a process which consists in crushing the ore and cleansing it at one operation with a flow of water and a magnetic separator. Limonite, the brown ore, is found in Peterborough, and hematite, the red, in Hastings and Lanark. Hematite ore also exists in what is believed to be large quantities on the north shore of lake Superior. Farther west, on the Mattawan river, a range containing specular and magnetic ores is found which is supposed to be a continuation of one or other of the great ranges of Minnesota—the Mesabi and Vermilion. Other ranges of magnetic ore, which are described as of vast extent, lie along the Atik-Okan river, a tributary of the Seine which flows into Rainy lake. These ranges have been traced a length of ten or twelve miles, rising in places 200 feet above the plain, and the ore is said to be very rich and clean. There are many other outcroppings of iron ore besides the ones I have mentioned; yet it has to be confessed that there is not a working mine in the province, for which the only consolation is that we have got the ore still, and that it may perhaps be more valuable in some day to come, when other great deposits in America are worked out.

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* The Copper-bearing Rocks of Lake Superior, by Roland Duer Irving, pp. 341-7.

Nickel is the most important of all our ores, and there are inexhaustible supplies of it in the country north of Georgian bay. Nearly fifty years ago nickel was found with copper on what is known as the Wallace location, near the mouth of Whitefish river. It was found also on Michipicoten island; but at neither place is it known to exist in workable quantities. The construction of the Canadian Pacific Railway led to the important discoveries that have been made in the district of which Sudbury is the centre. A railway-cutting through one of the rocky ranges exposed the ore, which at first was supposed to be copper pyrites, but which six years ago was ascertained to carry nickel as well as copper. Explorations and workings made since have resulted in proving that the Sudbury district is richer in nickel ore than any other known part of the world, and two engineers of the United States navy department have reported 650,000,000 tons of ore in sight. The data from which this estimate was computed may not have been absolutely trustworthy, but we know that other large and rich discoveries have been made since those engineers visited the district, and there can be no doubt of the vast extent of the ore. Eight mines are being worked, three large smelting plants are in operation, and as the demand is said to far exceed the supply the reports we hear of enlarged development of the mining and smelting industries of the Sudbury field will find ready acceptance. The value of nickel when united with steel, producing an alloy which combines hardness with strength and freedom from fracture under the strain of heavy blows, has been so amply demonstrated that the secretary of the United States navy department has decided to construct the armor plate of all his battle-ships with it; and the British admiralty has recently decided to use it largely for the same purpose, extensive orders having been placed for nickel-steel armor which forms the secondary defence of the battle-ships now in progress. There are various other objects for which this alloy is well suited, such as in the making of cannon, small arms, boilers and machinery, cutlery, etc., where strength, malleability, capacity to take a fine polish and freedom from rusting are valuable properties. Besides, there are many uses in the arts to which the pure metal may be applied when produced cheaply and in large quantity; so that we may look forward with confidence to great activity in the working of the nickel mines of this province, and, possibly as growing out of it in a natural way, to the awakening of our dormant iron mining industry also.

The silver-producing district of our province is confined almost exclusively to rocks of the Animikie series in the Cambrian system, lying to the north and west of Thunder bay in lake Superior. The veins which carry silver are found cutting ranges of table-topped hills or mountains whose summit is basaltic trap and whose base is black slate. Underlying the slate are beds of chert and jasper of extreme hardness which contain a percentage of iron, and it is found that the mineral veins in these beds are much leaner in silver than in the slates. The observation of this fact has depreciated to some extent the value of silver mines in the district, but recent accounts give rise to the hope that beneath the cherts the veins become enriched again. Silver Islet mine, which lies in lake Superior south of the Thunder Cape promontory, was one of the earliest discoveries in that region, and from its opening in 1870 to the suspension of work in 1884 the value of the silver output was $3,250,000, the total depth reached being 1,230 feet. Although the vein of this mine has been explored on the mainland for about a mile, no silver ore has been found; the only productive part of it is at the intersection of the dyke which constitutes the islet, and out of which the silver is supposed to have been deposited. Other mines in this district, the best known of which are the Beaver and the Badger, have yielded large quantities of ore during the last four or five years, but if they have been worked profitably the fact has been carefully concealed. It may require more capital and skill than have yet been employed to give them a thorough test.

There are other metalliferous ores in the province, but I shall refer only to one other, viz., blende or the sulphide of zinc. A large vein of it exists on the White Sand river about ten miles from the north shore of lake Superior. This was discovered eleven years ago, and it is claimed that the ore may be mined with great facility, but for want of a road it cannot be brought to market. A specimen analysed by the chemist of the Geological Survey gave 54½ per cent. of zinc. Another vein has been discovered a short distance from the head of Thunder bay.

II. In structural and decorative materials Ontario is richer than most countries, both as regards variety and quality. Sandstones, serpentines, marbles and granites abound in the northern districts, while in the south we have sandstones, limestones, clays and the materials for the manufacture of cement. Native cements are obtained from limestones in the Niagara formation at St. David's, Thorold and Limehouse, and in the Trenton at Napanee Mills. Portland cement is now being manufactured out of shell marl, large quantities of which are found deposited in shallow or extinct lakes, the marl being mixed with certain proportions of clay of a suitable quality, after which it is baked in a kiln and ground to a fine dust. Clay for common brick and tile is taken from deposits of the Saugeen and Erie clays; while for the manufacture of pressed brick and terra-cotta the shales of the Medina and Hudson River formations are used. The brown Medina shale, which crops out along the base of the Niagara escarpment at frequent points between the Niagara river and Owen Sound, has a depth ranging from 400 to 600 feet. The Hudson River shale crops out along the valleys of the Don and Humber rivers, and is probably of as great thickness as the Medina, although not so accessible. A few years ago all the pressed brick used in Ontario had to be imported from Ohio and Pennsylvania, but a better quality is now produced at home. Its introduction is bound to greatly improve the architecture of our towns and cities.

III. Mineral pigments or natural paints are obtained in a number of localities, and some of them are very abundant Sulphate of barytes is used as an adulterant with white lead. It is found in many of the veins on the north shore of lake Superior, and sometimes, as on McKellar's and Jarvis islands in lake Superior, makes up a large part of the vein. In the eastern part of the province, but especially in the county of Lanark, there are numerous veins of this mineral. Ochres are clays of various colors, such as red, yellow and green. At Limehouse on the Grand Trunk Railway a variety of colors is obtained, and pigments have been manufactured there for many years, as also at a point in the same formation farther south in the township of Nelson. Yellow ochre is a mixture of clay and limonite or the brown ore of iron, while red ochre is a mixture of clay with the specular or hematite ores of iron. Large deposits of the latter of fine quality are found in the counties of Lanark and Frontenac, one of which is 30 feet wide and three-quarters of a mile long; while another, which has a rich bronze hue, has been explored with a diamond drill to a depth of 65 feet.

IV. Mineral fertilizers exist as marls, gypsum, and apatite or phosphate of lime. The last named occurs as veinstone in the upper rocks of the Laurentian formation in various parts of the counties of Frontenac, Renfrew, Leeds and Lanark, but mining has been carried on chiefly in Frontenac and Lanark. The mineral is rich, but it is difficult to mine, and most of the deposits are remote from railway communication. During the past year the industry suffered partial collapse owing to the discovery and working of large surface deposits in Florida and the shipment of great quantities to the European markets. Gypsum is found over a large area in the Onondaga formation which underlies the counties of Brant and Haldimand, where mines have been worked for half a century. As plaster of Paris it has been largely used as a fertilizer for grass land, and when calcined it is used to finish and decorate walls. There are very extensive deposits also on the Moose river and its tributary the Missinaibi.

V. Mineral waters and rock salt are of limited occurrence in Ontario, but while the latter occupies one field the former are found in a number of localities and at points far distant from each other. Salt beds in the Onondaga formation extend over an area of 1,200 square miles in the counties of Bruce, Huron, Lambton and Kent. These beds no doubt were originally deposited at the bottom of inland seas as their waters gradually dried up. The total depth of the beds in Huron is about 100 feet, gradually thinning out to the edge of the basin; but a boring near the river Thames in Kent is reported to have gone through one bed of white salt 171 feet in thickness. The supply is sufficient to last our province for centuries; yet it is small when compared with some other known deposits of rock salt, such, for example, as the massive accumulations at Sperenberg, near Berlin, which have been bored through to a depth of 4,200 feet, or those of Wieliczka in Galicia which are more than 4,600 feet thick. The annual make of our Ontario wells ranges from 350,000 to 400,000 barrels, and owing to the restricted market this limit of production was reached nearly twenty years ago. Mineral waters impregnated with sulphur and salt are found very generally in the western part of the province, when deep borings are made in rocks of the Upper Silurian and Devonian systems; whereas in the eastern section of the province they are alkaline waters and are found to issue from rocks of the Lower Silurian system.

VI. Refractory minerals are such as require an extraordinary degree of heat to fuse them, or as are altogether infusible,,among which may be named actinolite, asbestos, graphite, mica and talc or steatite. These are found in commercial quantities in the eastern counties of the province, in rocks of the Laurentian formation. They have not yet however been worked upon a large scale, with perhaps the exception of mica. This mineral, from its possessing good insulating properties, has recently come into extensive use in connection with electrical machinery, and last year 240 tons of it were mined in Ontario.

VII. Materials of a mineral character used in the production of light and heat are not of first class importance in Ontario, being limited to petroleum, natural gas, lignite and peat. They are all of organic origin; the two former derived from animal or vegetable fossils, and the two latter from vegetable only. Our petroleum area at one time extended over portions of Lambton and Kent, but the producing field is now wholly confined to a few thousand acres in Lambton. It is obtained from the Corniferous limestone, but the original source may have been in lower formations. Natural gas is a recent discovery, but reservoirs of good producing capacity have been struck by borings in the counties of Essex, Haldimand and Welland. In Essex the gas rises, it is supposed, from the Clinton formation, whereas in the two eastern counties it rises from the Medina sandstone. Extensive beds of lignite have been discovered interbedded with the drift in the basin of the Moose river and its tributaries, the Abittibi and the Missinaibi. But the peat deposits of the Hudson bay slope have a vastly greater area, and when the time comes, as doubtless it will come, that peat can be converted into good fuel at an economic price, a material of first class necessity will be obtainable for the people of Ontario in limitless quantity. Nor, when that time comes, will we be dependent on the peat bogs of the Moose river basin alone. There is hardly a county in the province which does not possess a supply; there are large beds between the Ottawa and St. Lawrence rivers; our lake country is full of it; and along the line of the Canadian Pacific Railway from the Ottawa river to Lake of the Woods there is more of it than would replace the coal fields of Pennsylvania. And it is with some confidence I express the belief that in a process which I had an opportunity of looking into a few days ago the problem of the conversion of peat into fuel has already been solved in a simple, practical and economic way.

So I come to the end. The subject is very far from being exhausted, but I know that I must have wearied your patience if I have not exhausted your forbearance. Let me however express the hope that something has been said which may serve to arouse in your minds a higher opinion of this great Ontario of ours—the first commonwealth of America in the extent and variety of its resources, in the commanding opportunity of its situation, in the excellence of its institutions and the sterling qualities of its men. If I was to give a word of counsel concerning your relations to this commonwealth, the duty you owe to it and the sphere you should aspire to occupy in it when you also become men, it would be only in the words of the Spartan mother when her son was leaving farewell on going out to meet the enemy of his country and might not evermore return:

SPARTA IS YOUR PORTION, she said—DO YOUR BEST FOR SPARTA!

PEAT, ITS USE AND VALUE FOR FUEL.

Nature, which has dealt of her mineral treasures to our province with no niggard hand, has denied her the gift of coal. The Carboniferous series has no place in the geology of Ontario, nor have the Cretaceous areas of the Northwest Territories and British Columbia with their important and extensive coal deposits their counterparts here. It cannot be contended that this gap in the geological record is a matter of little consequence. In the bracing atmosphere of our northern winters personal health and comfort require a generous consumption of fuel, the cost of which forms no small share of the householder's annual expenditure. Time was when the hardwood forests which covered a great part of Ontario could be drawn upon for what seemed endless supplies of fuel, and with first-class cordwood at very little more than the cost of cutting and hauling, the question of fuel was not one to give any concern to the early settler, or his sons who succeeded him. Rather did they zealously strive in season and out of season to get rid of this magnificent supply of timber, until we who live in these latter days are inclined to think they succeeded but too well. To a large part of the population of the province wood has ceased to be the chief fuel and has given place to coal, almost entirely the product of the mines of Pennsylvania and Ohio. The long vessel and railway carriage and consequently heavy freight charges to which the coal we use is subject makes it impossible that the price should be otherwise than high, and the cost of coal both for domestic and industrial use is a heavy tax upon the productive energies of our country.

SUPPLY AND COST OF FUEL.

Statistics of the quantity or value of the fuel annually consumed in Ontario are not to be had, yet an approximation may be made which will show how largely this item bulks in the expenditure of the country at large.

The number of families in the province may be taken as 400,000, averaging five persons in each. A moderate estimate will allow ten cords (of 128 cubic feet) of wood or six tons of coal to each family per year, not taking into account the very large quantities of both wood and coal consumed by the railways and industrial establishments of the province. At the present time hardwood retails in Toronto at $5.50 per cord and anthracite coal at $6.00 per ton, and in other large towns and cities the prices are much the same. In country towns and villages in well settled districts the best hardwood costs $3 50 and $4.00 a cord, in more remote sections not so much, while the cost of coal is enhanced the farther it is taken inland from the border line between Ontario and the United States. The price of wood and coal varies also for the several varieties of each, but if it may be assumed that the cost to the consumer all over the province is three dollars per cord for wood and five dollars per ton for coal, we arrive at a yearly outlay per family for fuel of $30, or an annual expenditure for the province at large of $12,000,000 for fuel for domestic use alone. The annual cost per family for fuel from 1885 to 1889 is given in the report of the Bureau of Industries for 1889 as $40.12, which would give a yearly expenditure for the province of upwards of $16,000,000; the figures however have reference to the artisan classes in cities and towns only, and do not include the farmers or dwellers in rural districts who are much more numerous than the working classes (so-called) and whose fuel costs much less. It is therefore probable that $40.12 is in excess of the average expenditure per family for fuel throughout the whole of the province.

To the annual value of the fuel consumed for domestic use must be added the cost of fuel used by the railways, the steamboats and the thousands of manufacturing establishments throughout the province. This sum must be a large one. The total imports of coal into Ontario for the year ended 30th June, 1891, were, bituminous 1,510,411 tons, valued at $4,708,343 (including duty), and anthracite 931,463 tons, valued at $3,516,041; a total of 2,441,874 tons, valued at $8,224,384. If we suppose that one-half of this quantity is consumed for transport and industrial use, we get a total expenditure for fuel for all purposes of not less than $16,000,000 a year.

DEPENDENT ON A FOREIGN COUNTRY.

The forests and woodlands still supply a large share of this fuel, particularly of that part used in country districts both for domestic and industrial purposes, and will probably continue to do so for some time to come, but for the remainder we are dependent upon a foreign country.

Combines of coal-mine owners or railway companies, strikes or lock-outs of miners or railway employés, financial or other disturbances, all occurring in another country and entirely beyond the control of our own people, are causes which may at any time bring about a scarcity of coal and an advance in its price.

These are no imaginary dangers. A recent amalgamation of railway and coal-mining companies in the United States has placed the control of the coal product in the hands of a few owners, and the inevitable result has been the "stiffening of coal values," otherwise a rise in the price of coal. The cost has gone up to consumers in this city fifty cents per ton, with the prospect of further increases during the season; and the unpleasant truth has been forcibly brought home to the coal users of the province that they are delivered over to the tender mercies of a coal ring which has the power and apparently the intention of squeezing every cent it can out of the market. Were such combinations formed in Ontario, Canadian legislation might perhaps be brought to bear upon them; but they are beyond the reach of our lawmakers, and not having coal within their own borders the people of this province, unpalatable though the thought may be, are doubly harnessed to the car of one of the most odious of monopolies—a monopoly in a prime necessary of life.

Our national pride cannot reasonably take offence at the decree of nature which obliges us to import our coal from the United States, yet surely, in addition to the considerations mentioned above, it may and ought to furnish a stimulus to the examination of our own resources in the hope of obtaining an article therefrom which would be to some extent at least a substitute for coal, and which would create a new industry and provide new employment for the labor and enterprise of our citizens.

IRON WITHOUT COAL.

Abundant supplies of good coal and iron are at the foundation of England's prosperity and her industrial and commercial supremacy. Iron alone would have been of comparatively little avail had she not had the coal with which to smelt it, nor would the coal alone have served her had she not had vast stores of ironstone close by out of which to win the raw material for her ships, her guns and her machinery. Similar in kind, if not in degree, have been the results wherever stores of these minerals have been confided to the hands of a people who knew how to make use of them. The amazing progress in all the arts of peace and industry made by the United States, which threaten to eclipse even that of the mother country herself, the rapid strides in the same direction made by France, Germany, Belgium and other European nations have all depended to a very large degree upon the possession by these countries of beds of iron and coal.

Here in Ontario we have iron; iron of the best quality and in immense quantity. It is found in the east, in the north and in the west, and there is every likelihood that in the many unexplored parts of the province future prospectors will bring fresh deposits to our knowledge. But we cannot hope, however diligently our prospectors may search, that their efforts will be rewarded by finding workable measures of coal. We know that in the almost untrodden wilderness where the Moose and Abittibi rivers flow northward into James' bay there are deposits of lignite, but their extent and value are yet undetermined, and it would be rash to say that we may expect the Hudson bay slope to supply us with lignite of good enough quality and in sufficient quantity to take the place of the anthracite and bituminous coals from the mines an equal or less distance to the south of us.

THE SUPPLY OF PEAT.

There remains another source of heat which though hitherto but little availed of among us holds great possibilities of usefulness for Ontario. Peat exists in very large quantity in the province, but for various reasons has as yet met with little acceptance as fuel. People dislike to change their ways unless they are obliged to do so, and hitherto both wood and coal have been sufficiently abundant and cheap to give them no reason to look to other substances for fuel. The chief hindrance to the use of peat has lain in the difficulties which are met with in the effort to reduce the raw material to a serviceable article at a cost which will allow of competition with wood or coal. Many ingenious attempts have been made both here and in other countries to overcome these difficulties, and much time and money have been spent upon processes of greater or smaller promise, but up to the present time the results have not been wholly satisfactory. The wit and skill of inventors continue however to be addressed to the task, and there is reason to hope that ere long the ingenuity of man will have triumphed, and another victory will have been scored of mind over matter. Some of the most promising of the attempts to surmount the obstacles which present themselves in the economic preparation of peat fuel have been made in Canada, and at least two processes have recently been brought to the notice of the Bureau by which it is hoped that Canadian inventors have solved the problem. ·

ORIGIN AND NATURE OF PEAT.

Before entering into an account of the difficulties which lie in the way of the utilization of peat, or of the various methods which have been adopted in the hope of overcoming them, it is necessary to devote a few words to the origin and nature of peat itself. In low and moist situations, particularly in the more northerly and colder regions of the globe, where water collects and cannot readily flow off, a growth of a low order of vegetation is induced, consisting of mosses and marsh-plants of various kinds. The plant which is the principal source of peat is a moss of the genus *sphagnum*, of which there are many species, all having the peculiarity of dying at the extremity of the roots below while continuing to grow and increase above the surface. The botanical characteristics of this moss are given by Braithwaite in his work on Peat Mosses as follows:

> Plants densely aggregated, without roots except in the young state. Stem with the axile cells soft, becoming indurated at the surface, clothed with a cuticle of one or several layers of large lax cells. Leaves nerveless, of a single stratum of dimorphous cells, the small utricular ones conveying sap and chlorophyl, enclosing the large, empty hyaline ones, which generally contain spiral fibres and have their walls perforated by large or small foramina. Inflorescence axillar, the male amentiform, antheridia globose, with very fine, branched paraphyses. Capsule globose, sessile on the apex of an elongated vaginula; calyptra saccate. Branches in lateral fascicles, aggregated at summit into a dense coma.*

The same author says further:

> Between fifty and sixty species of *sphagnum* are known, of which about one-third are tropical; but they are most abundant in the north and south temperate zones, in the higher latitudes of which they cover a great expanse of surface. . . . As to the economic uses of the sphagnaceæ, they are but small, except as a source of easily procured fuel; and in this respect indeed they are of immense importance, for no substitute could be found in the thinly populated and barren districts of the north, where trees become an insignificant object in the scenery, or cease to grow at all; yet nature, by the very means which produce these widely extended solitudes, supplies one of the first requirements of those who occupy them, and everywhere is peat annually cut, dried and stored. With regard to the function of these plants in the formation of peat, I cannot do better than quote Professor Schimper's words. He says: 'Unless there were peat-mosses, many a bare mountain ridge, many a high valley of the temperate zone, and large tracts of the northern plains

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*Braithwaite: The Sphagnaceæ or Peat-Mosses of Europe and North America, (1880) p. 10.

would present a uniform watery flat, instead of a covering of flowering plants or shady woods. For just as the *sphagna* suck up the atmospheric moisture and convey it to the earth, do they also contribute to it by pumping up to the surface of the tufts formed by them, the standing water which was their cradle, diminish it by promoting evaporation, and finally also by their own detritus, and by that of the numerous other bog-plants to which they serve as a support, remove it entirely, and thus bring about their own destruction. Then, as soon as the plant-detritus formed in this manner has elevated itself above the surface water, it is familiar to us by the name of peat, becomes material for fuel, and all *sphagnum* vegetation ceases.'*

Where the conditions are favorable peat-beds of considerable thickness are often accumulated in the course of time. The growth of these beds is occasionally quite rapid. Geikie says for instance, that in the valley of the Somme three feet of peat will grow in from thirty to forty years; on a moor in Hanover a layer of peat from four to six feet thick is formed in about thirty years, while near the lake of Constance a layer of three to four feet grew in twenty-four years. When a considerable growth has been attained decomposition sets in, gases are evolved, and the mass assumes a considerable density and becomes of a dark earthy color. The layers nearest the surface are for the most part less compact and of a lighter color than those below, and are less valuable for fuel.

Peat bogs often occupy the site of shallow lakes which have been overrun by vegetation, and in such cases the peat is frequently found resting upon a layer of marl made up of the shells of countless myriads of shell-fish which formerly inhabited the waters. Such marl, consisting principally of carbonate of lime, is valuable as a fertilizer on certain soils and is also used in the manufacture of Portland cement.

CONSTITUENTS OF PEAT.

Peat generally contains a proportion of incombustible matter such as sand, lime or other inorganic substances washed into it by the drainage of the surrounding country or blown into it by winds. These constituents vary in proportion from 1 to 33 per cent. and largely determine the quantity of ash produced by the combustion of any sample of peat. The better qualities of peat seem to yield from 3 to 8 per cent. of ash, and those which contain a much higher percentage are less valuable or altogether worthless for fuel. Deducting the incombustible matter and water, the average composition of air-dried peat may be said to be as follows: Carbon, 52 to 66; hydrogen, 4.7 to 7.4; oxygen, 28 to 39 and nitrogen 1.5 to 3 per cent. The following table from Percy's Metallurgy shows the position which peat occupies as a fuel as compared with wood and coal, carbon in each case being taken at 100:

Substance.	Carbon.	Hydrogen.	Oxygen.	Disposable hydrogen.
1. Wood (mean of several analyses)	100	12.18	83.07	1.80
2. Peat " " "	100	9.85	55.67	2.89
3. Lignite (mean of 15 varieties)	100	8.37	42.42	3.07
4. Ten-yard coal of S. Staffordshire basin	100	6.12	21.23	3.47
5. Steam coal from the Tyne	100	5.91	18.32	3.62
6. Pentrefelin coal of S. Wales	100	4.75	5.28	4.09
7. Anthracite from Pennsylvania, U.S.	100	2.84	1.74	2.63

"Disposable hydrogen" in the above table refers to the proportion of that gas over and above what is required in combination with the oxygen to form water. It will be observed that while the proportion of hydrogen decreases in descending order in the above table, the proportion of oxygen decreases in greater ratio, the consequence being of course that less of the hydrogen is taken up by the oxygen in the formation of water and more is available for purposes of combustion. The percentage of "disposable hydrogen" is therefore a partial index of the value of a fuel.

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* The Sphagnaceæ or Peat-Mosses of Europe and North America, pp. 8, 10, 11.

COMPOSITION OF FOSSIL FUELS.

The following figures are extracted from tables given in Percy's Metallurgy, and will suffice to show the chemical composition of peat, lignite and some of the principal varieties of coal.

—	Peat.	Lignite.	Caking coal.	Non-caking coal.	Cannel coal.	Anthracite.
Carbon	54.02	66.31	78.69	78.57	80.07	90.39
Hydrogen	5.21	5.63	6.00	5.29	5.53	3.28
Oxygen	28.18	22.86	10.07	12.88	8.08	2.98
Nitrogen	2.30	0.57	2.37	1.84	2.12	0.83
Sulphur	.56	2.36	1.51	0.39	1.50	0.91
Ash	9.73	2.27	1.36	1.03	2.70	1.61
Specific Gravity	0.850	1.129	1.259	1.278	1.276	1.392

These analyses are exclusive of water, which in the peat amounted to 25.56 and in the lignite to 34.66 per cent.

The following table by Dr. Wagner, quoted by Thurston, gives a somewhat different analysis of fuels, and also represents approximately the gradual change of composition as fossilization affects the alteration of the woody fibre* :

—	Carbon.	Hydrogen	Oxygen.
Cellulose	52.65	5.25	42.10
Peat	60.44	5.96	33.60
Lignite	66.96	5.27	27.76
Lignite (earthy brown coal)	74.20	5.89	19.90
Coal (secondary)	76.18	5.64	18.07
" "	90.50	5.05	4.40
Anthracite	92.85	3.96	3.19

In the above analyses earthy matter is excluded.

Peat is simply one of a group of fuels of vegetable origin which, beginning with the most recent of wood or other plant growth, extends downward to the oldest anthracite. We can readily detect the difference between the various members of the group, but are often at a loss to know where one ends and another begins. For example, wood is quite distinct in physical properties and chemical composition from lignite, and yet specimens of lignite, such as those brought by Mr. Borron from the Moose river, are found showing the scarcely altered wood passing into true lignite, and when the latter is met with approaching the bituminous coals in age it also approximates them in structure and other characteristics. Bituminous coals again probably differ from anthracites only because of their later origin. Similarly, peat taken from the bottom of a bog where it has lain for a long time and has been subjected to heavy pressure is dark brown or black in color, possesses comparatively little external appearance of vegetable origin and is scarcely distinguishable from some forms of lignite. Peat in short may be regarded as incipient coal.

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*The Materials of Engineering, by Robert H. Thurston, A.M., C.E. (1884) Part I p. 173.

THE NATURE OF FUEL.

Fire was one of the "elements" of the ancients, but modern science has long since removed it from that category, along with its companions, earth, air and water. Fire indeed though called "the destroyer" is but the energetic indication of a change taking place in the chemical composition of the substance upon which it appears to feed. It annihilates nothing; it only destroys the form in which matter has previously existed, and re-arranges its constituents into some other combinations. The combustion or burning of a fuel is simply the process by which the elements it contains are oxidized or combined with oxygen—usually with the oxygen of the atmosphere. The principal heat-producing elements of ordinary fuels are carbon and hydrogen, and the heat given out by the fuel while burning is evolved by their oxidation. The carbon unites with oxygen to form carbonic oxide (CO) or carbonic acid (CO_2) while hydrogen unites with oxygen to form water (H_2O). A fuel may be judged by the *total amount* of heat, or by the *intensity* of heat, which its combustion is capable of producing. The following extract from the Encyclopædia Britannica states succinctly the difference between these two things:

> In the determination of the value of fuel two principal factors are involved, viz., the calorific power, or the total amount of heat obtainable from the perfect combustion of its constituents, and the calorific intensity or pyrometric effect, which is the temperature attained by the gaseous products of the combustion. The first of these is constant for any particular composition and does not vary with the method of combustion, the quantity of heat developed by the combustion of a unit of carbon or hydrogen being the same whether it be burnt with oxygen, air, or a metallic oxide. The calorific intensity, on the other hand, being inversely proportional to the volume of gases produced, it is obvious that if the combustion is effected with pure oxygen the resulting carbonic acid (in the case of carbon) may be very much hotter than when air is used, as the duty of heating up an additional quantity of nitrogen rather more than three times the weight of the oxygen is in the latter case imposed upon a similar weight of carbon.*

In his Elements of Metallurgy Phillips states that "From the mean results of a considerable number of experiments 8,080 (metric heat units) has been decided on as the calorific power of carbon existing in the form of purified wood charcoal, while from the mean of six determinations Favre and Silbermann deduced 34,462 as the calorific power of hydrogen, the weight of hydrogen consumed being calculated from that of the water collected."† The calorific intensity of a fuel cannot be so easily ascertained, being dependent not only on the composition of the fuel itself but also upon various circumstances connected with the mode of combustion. "All calculations," says Phillips, however, "made on this subject so far agree with the result of experience as to show that, practically, the temperature which a fuel is capable of producing is directly proportionate to the amount of carbon it contains."‡ This author defines a fuel in the following terms:

DEFINITION OF A FUEL.

Any substance which admits of being rapidly oxidised or burned by atmospheric air, and evolves during that operation an amount of heat capable of being applied to economic purposes, is called a fuel. Two elements only, namely, carbon and hydrogen, are thus applied. All fuels are of vegetable origin and chiefly consist either of woody tissue or of various products of its natural or artificial decomposition. Although vegetable matter is never free from traces of nitrogen it may be regarded practically as being essentially composed of carbon, hydrogen and oxygen, together with small amounts of earthy or inorganic substances. In all fuels containing carbon, hydrogen and oxygen the proportion of hydrogen may be equal to or greater than that required to form water with the oxygen, but is never less. In such combinations only the hydrogen in excess is considered available as a source of heat, so that in the combustion of a substance of which the composition may be regarded as carbon and water the carbon alone is the source of heat. Indeed in such cases the hydrogen is the cause of the loss of a considerable amount of otherwise available heat, since it may be viewed as existing in combination with oxygen in the state of water, which must be evaporated at the expense of a portion of the heat developed by the combustion of carbon.§

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* Encyclopædia Brittannica, article Fuel, vol. IX. p. 807.

† A metric heat unit is the amount of heat required to raise one gramme of water from 0° to 1° C.

‡ Elements of Metallurgy by J. Arthur Phillips, M. Inst. C. E., etc. (1874), p. 23.

§ Ib., p. 15.

Thurston in speaking of fuels says:

The fuels used in metallurgy and engineering are anthracite and bituminous coals, coke, wood, charcoal, peat and combustible gases obtained by the distillation of the solid kinds of fuel. . . The heating power of any fuel is determined by calculating its total heat of combustion. This quantity is the sum of the amounts of heat generated by the combustion of the unoxidised carbon and hydrogen contained in the fuel, less the heat required in the evaporation and volatilization of constituents which become gaseous at the temperature resulting from the combustion of the first named elements.*

Fuel Value of Peat.

Dealing with peat the same author says:

Dried in the air it, like the lignites, retains moisture persistently, and is usually found to contain 30 per cent. after drying. After completely removing all water, an average specimen would contain about 60 per cent. of carbon, 5 to 10 per cent. hydrogen, and 30 or 40 per cent. of oxygen. The ash varies very greatly, sometimes being as little as 5, and in other cases as high as 25 per cent. A pound of wood charcoal has nearly the same value as a fuel as 1.66 pounds of peat of average quality. Peat is frequently used in large quantities for heating purposes, and attempts have been made, with encouraging results, to use it in metallurgical operations. When to be thus used it is cut from the bog with sharp spades, ground up in a machine specially designed for the purpose, and dried by spreading it where it can have full exposure to the sun and air. It is frequently compressed by machinery until its density approaches that of the lighter coals, and it is used in blocks of such size as are found best suited to the particular purpose for which it is prepared. Its charcoal makes excellent fuel for use in working steel and welding iron. It is frequently found to be a very excellent fuel for other purposes, and is extensively used in some localities. Its specific gravity is usually about 0.5.†

Thurston also gives a table showing the heating effects or calorific power of various fuels, from which the following is extracted, showing the value of peat in this regard as compared with other well-known fuels ‡ The calorific power is expressed in British thermal units, one such unit being the quantity of heat required to raise a pound of water from the temperature 39.1° to 40.1° Fahr.

Fuel.	Calorific power.		Water vaporized at boiling point parts by one part.	Cubic feet required to stow one ton of furnace coal.	Weight pounds per cubic foot as stowed.
	Relative.	Absolute.			
Coal, anthracite	1.020	14,833	14.98	40 to 45	49 to 56
Coal, bituminous	1.017	14,796	14.95	42 to 48	47 to 53
Coal, lignite, dry	0.7	10,150	10.35	42	53
Peat, kiln dried	0.7	10,150	10.25	81	25
Peat, air dried	0.526	7,650	7.73	75	30
Wood, kiln dried	0.551	8,029	8.10	....	....
Wood, air dried	0.439	6,385	6.45	56 to 100	22 to 40

The foregoing statements are sufficient to demonstrate the place of peat in the category of fuels. They show that it occupies a position both in composition and value intermediate between wood and coal. Leaving the proportion of water out of consideration, it contains a higher percentage both of carbon and available hydrogen than wood, but less than any form of coal, while in heating power, as measured by its capacity of evaporating water, it ranks in like order. In its ordinary forms it is also slightly less bulky than wood, but much more so than coal.

PEAT IN EUROPE AND AMERICA.

In the British isles and on the continent of Europe peat has been long in use as a source of heat, particularly among the poorer classes, to whom it possesses the recommendation of being generally obtainable at an outlay of little more than their own labor. Since railways and steamships have cheapened the transportation of coal, the use of peat has become less general, but at one time in Scotland and Ireland it was the fuel most largely made use of by the laboring classes, and indeed by the great bulk of the population. The right to take peat from a neighboring bog was one highly prized by the peasantry of those countries, and neither wood nor coal being available, it is difficult to see how life would have been sustained had it not been for the stores of fuel laid up in these bogs by the generous hand of nature. Generation after generation employed in the preparation of peat have given it its rules of manufacture, its appropriate tools of peculiar design, its vocabulary of technical terms and its place in song and story; and many inhabitants of this province, immigrants from the old lands, can speak feelingly of the days spent in "cutting turf" or "casting peats," and the comforts of a seat by the fire-place in winter when a mass of glowing peat sent out its mellow warmth, and spread abroad its pungent odor on the frosty air. Many such immigrants, now old or middle-aged, can well recall the days when, in cold weather, they trudged to school, each with a peat under his arm, as their contribution to the heating of the parish school-house.

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* The Materials of Engineering, part I. p. 154. † *Ibid*, pp. 177-8. ‡ *Ibid*, p. 207.

ITS PREPARATION IN SCOTLAND.

The methods of preparing common air-dried peat fuel are practically the same in all countries, differing only with the nature and particularly with the consistency of the material. In bogs of the usual character the surface is first removed, that portion being of little value for fuel, and the denser part is then cut into brick-shaped blocks which are placed in convenient position for drying. When the latter process is sufficiently advanced the product is ready for use, or to be stored away for consumption in cold weather. A minute description of the process of peat cutting and winning as practised in a lowland parish in Scotland is given by Mr. Alexander L. Gibson, of Wroxeter, Ontario, in a letter to the Bureau, and may be taken as typical of the methods employed elsewhere. It may be worth while to place on record an account of the methods employed in the preparation of the fuel which for centuries was almost the sole fuel of the people of Scotland, and Mr. Gibson's letter is therefore quoted in full. He says:

> The peat-moss that we dug our peats in, the Dogden moss, was situated in Greenlaw parish, Berwickshire. It was of very large extent, about 700 acres, and up to my early years had been very extensively worked for fuel. Peat was, even in my father's boyhood, an article of commerce, being carried to such places as Dunbar and Berwick-on-Tweed. The moss was quite contiguous to a hamlet called Bedshiel, where there were twelve families who each had a small moorland holding and kept a few sheep and some "eild" (in modern phrase, young) cattle. Along with their little farming operations they made a business of digging peats and carrying them to the places mentioned, which in the then condition of the roads was no small job. These men were called "peat lords," but that condition of things was done away with before my time. The Dogden moss lay a little distance south from the southern foot of the Twinlaw Cairns, say a couple of miles, and to the north of a gentle elevation of moorland, so that it is likely that at some time in the distant past it was an open lake, with an opening to the east draining into the Faungrass water. On the west were some sandy knolls, famous for rabbits; at this end the moss was partially drained by two routes into the Blackadder, through Halyburton farm. On the northeast were the kames, a high ridge of gravel, rather rough, covered with broom, whins and a wiry sort of grass. The direction of the kames was generally from northwest to southeast, with frequent bends and crooks from the general direction, and they terminated at the southeast end in a round conical hill of much higher elevation. The east end of the lake had evidently been dammed up during the glacial era, and vegetable matter springing up gradually raised the level of the lake until at last the water worked through to the west as above stated. It is to be noted that when in digging the peats we had the good luck to reach the bottom, we invariably found a layer of brush-wood, which as invariably seemed to be hazel.
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> In digging the peats the first operators ages ago commenced at the dry land, that is, where the moss and hard moorland meet, and kept cutting away, year after year, finding the moss gradually growing deeper and deeper until the moss-hag was about eleven feet deep and fully a quarter of a mile from the dry land. The peats, when dry, had to be carried this quarter of a mile, either on hand or wheel-barrows, as no horse or cart could reach the peats where they were made. The moss for about three feet deep consisted of "foggy" growth, and was comparatively worthless for fuel. The hag was a face about five or six feet high, and at the foot of this hag was the "hole" from which a portion of last year's peats had been taken; it was generally eight or nine feet wide, five feet deep, and

full of water when we came in the month of April or May to dig the peats for the season. The portion of the hag my father had was about fifty feet long of a face, and according to the quantity intended to be taken out it might be that we cut eight or ten feet in the hag, and dug out that block down to the bottom, when the water did not chase us out. The first process was to "turr" the top of the hag. This was done by cutting off with the spade the foggy top formerly mentioned, and throwing it into the last year's hole, thus forcing the water to find its way in any direction from the "lay ground." Each year's hole was filled up and levelled so as to form a ground on which to lay the newly cut peats till they partly dried. This part soon assumed the appearance of the original moss, and would no doubt after a time (how long I cannot say) again become fit to make peats.

We will now suppose that the block fifty feet by nine or ten is "turred" to the depth of about two feet or perhaps more, and we are ready to "cast" the peats. We take a sharp spade and make a cut about a foot and a half deep and about one foot or fourteen inches from the front of the hag, and six feet or so long. This is called a "bink," and we take the peat spade and cut out block after block about five inches square and a foot or fourteen inches long. Three peats deep will generally take off all that was "ritted," and we have to ritt again. We go on in this manner until the bink is out, that is, taken out down to the level of last year's hole. Bink after bink is excavated until the whole block that was turred is removed, and now as the most valuable part is under our feet we have to commence to "sink." In doing this we cut the peats sometimes not very shapely at first, and gradually working backwards we can cut them nearly straight down, giving them no more slant than will keep them from slipping off the spade. Having gone across the block we turn face and work in a similar manner back to where we began to sink. By this time we are about two feet or more below the level of the lower lay ground. We go on in this way until we reach bottom, which is invariably a fine white sand, and having got our hole sunk we now again turn face to the right or left as required and go on bink after bink until all is out. I am proceeding on the assumption that we have had good luck, which simply means that we have not come across a "gaw," or fissure in the moss, full of water. If we do we must abandon the hole, for it soon fills up, and sink again, leaving a "scarcement" or wall between the new hole and the abandoned one. Now that we have the peats cut we have to carry them away back and lay them out to dry. The first row is laid flat down, and the next with one end of the peats resting on those first laid down and the other end on the ground, so that a current of air circulates below and around them. They lie in this way for about two weeks, if the weather is favorable, and the next process is to "foot" them, *i,e.*, placing four or five together on end leaning to a common centre in such a way that they will stand, and then laying one, two or three on top as may suit. After they have reached this stage they are comparatively safe and are getting quite hard. A week or two weeks more makes them ready for stacking, when they are considered almost secure. When first cut the peat is of a brown color but on a few minutes exposure to the air turns as black as coal. In drying it decreases about fifty per cent. in bulk, and is lighter than coal when dry. I cannot say anything as to its value compared with coal or wood; very little of the latter is used by common people in Scotland.

In some parts of this large moss there are occasionally met what are termed "wigs." These are the roots of some sort of grass that have never rotted, and it is almost impossible to cut them, as they just push before the spade into the soft moss and cause great trouble and hindrance in the work. In some mosses in the neighboring parish of Gordon they do not need to ritt the bink, as they use a "lippy" spade, one push of which forms a peat. In our moss we could scarcely use a lippy for fear of coming across a wig.

This peat is a very valuable article of fuel. It is much cleaner in every way than coal: it gives very much less smoke, almost no soot, and is easily kindled. The peats from the lower part of the moss become quite hard and black when fairly dry. The smell of the smoke is very strong and is perceptible three or four miles away, but is not disagreeable to the natives, though people from districts where coal is used do not like it. When burning the peat does not burn with a flame, but gets into a fine red glow until it is consumed to ashes, of which it does not leave much.

PRICE OF PEAT FUEL IN SCOTLAND.

Peat is now but little used in Scotland; indeed except in the more outlying places which are far from coal and in the Highlands, whence coal is brought from England, peat is largely a thing of the past. In former days the cost of the labor required to cut and save peat was less than the price of coal, but with the rise in the wages of labor and the extension of transport facilities peat has been very largely supplanted by its heavier and more compact rival. At the present time peat fuel prepared in the ordinary way sells in Scotland for about 13 shillings per ton (2,240 lb.), of which 8 shillings 6 pence covers the cost of labor, the price of coal in the same market being from 13 to 18 shillings 6 pence per ton. It is used for domestic purposes only, and 1 ton 18 cwt. is considered equal in heating value to one ton of coal.

THE PEAT INDUSTRY IN IRELAND.

In Ireland, on the other hand, at any rate in the south of Ireland, the use of peat or "turf," as it is there called, where available, is said not to be on the decline. A recent letter from Mr. J. O'Keeffe, a hardware merchant in Tralee, county Kerry, Ireland, says that "peat is used by the great majority of the rural population in Ireland wherever such can be obtained, but like the great forests of Canada, vast tracts of the bogs of Ireland are already used up, and in some counties the railways have facilitated the mode and cost of transit." Mr. O'Keeffe states that peat is not only used for domestic purposes, but that in dairy and baking operations it is invaluable, and that the dairymaid and butter-maker in Ireland attribute the excellent quality of their butter to the use of peat fuel. It is also employed under steam boilers in small mills in the country districts where water power is not available, and for the driving of engines attached to threshing machines. The average cost for labor per ton is three shillings for peat saved on the sward. In Tralee market the present (July, 1892) price of peat is about 5 shillings per ton as compared with 23 shillings per ton for Welsh and 18 shillings per ton for Scotch coal, delivered. Two tons of "first cutting" peat are considered to be equal to one ton of Scotch coal and two and a half tons to one ton of Welsh coal.

The method of cutting and preparing the peat is described by Mr. O'Keeffe as follows: Cutting usually commences about 1st May, a short spade about six inches wide at the mouth with a wing at the left side being used, which cuts and squares the sods at one operation. Attending each digger is a man with a two-pronged fork having a handle 5 to feet long, who throws the sod to another, who in turn throws it to another, and so on until the limit of his "sward" or drying-ground is reached. The last person who receives the sod generally spreads for drying, leaving the sods almost horizontal, for if placed perpendicular, or nearly so, and the summer should become rainy or wet the process of drying is slow as well as expensive. Placed in the position first described the "turf" comes in earlier. The process of drying usually takes about two months, but in a season like the present, which has been exceptionally favorable, it has been dried and saved within five weeks.

Mr. O'Keeffe concludes: When peat is plentiful and cheap large fires are kept continually burning, over which generally hangs a large three-legged or sometimes a flat-bottomed pot, and in another part of the premises is a portable boiler for the heating of which peat answers admirably. In the winter-time the housewife feels proud of "the blazing fire high-piled upon the hearth" beside which the stories of a thousand years are told. In many Irish towns where people use ranges very little peat is burned, except for baking purposes, but in the poorer quarters where the open hearth is still in vogue and where the luxury of a range is unknown, it is the fuel used for all domestic purposes. In rural Ireland coal is very seldom used, and will not be for many a year to come.

EXTENT OF EUROPEAN DEPOSITS.

There are very large deposits of peat in England, Scotland, Ireland, France, Holland, Germany, Austria and elsewhere in Europe. It has been estimated that the amount of peat fuel in Ireland, taking the value of crude peat compared with that of coal as 1 to 6, is equivalent to four hundred and seventy million tons of coal, while in France there is said to exist the enormous quantity of six thousand million tons of peat purified and dried in the crude state, or reduced to charcoal two thousand six hundred and ten millions of tons. Mr. O'Hara, in the Dublin Quarterly Journal of Science, estimates the peat-bogs of Ireland at 1,576,000 acres occupying the limestone plains, and 1,255,000 acres on the hills and mountains, making a total of 2,831,000 acres. Mr. Plant estimates the extent of peat in Great Britain at 3,500,000 acres, therefore the total in the British Isles will be about 6,000,000 acres; consequently if 12 feet is assumed as the average thickness, each acre will yield 12,000 tons of peat, on the whole at least 72,000,000,000 tons of valuable fuel.* The peat bogs of other European countries are on a similarly large scale.

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*Ure's Dictionary of Arts, Manufactures and Mines (1875) vol. III. p. 527.

PEAT DEPOSITS IN AMERICA.

Nor is there any scarcity of this article in North America. The New England and Atlantic states comprise within their borders large peat areas, the great stretch of the Dismal Swamp apparently forming its southern limit in the United States. Peat is found in all the provinces of Canada, the bogs of New Brunswick and Quebec being very extensive. In Ontario, Logan in The Geology of Canada (1863) says:

VARIOUS OCCURRENCES IN ONTARIO.

It occurs in the township of Caledonia, where its thickness does not appear to exceed three or four feet, also at the sources of the Pain river in Roxburgh, Osnabruck and Finch, and in Clarence, Cumberland and Gloucester. In the third, fourth and fifth ranges of the latter township is a tract known as the Mer Bleue, which consists of two long peat bogs separated by a narrow ridge of higher land and occupying each about 2,500 acres. These deposits were sounded in many places with a rod to a depth of twenty-one feet, without finding bottom; in other parts the peat was from eight to fifteen feet in thickness. This tract is situated only three miles from the Ottawa, and is about 280 feet above the level of the sea. Three large areas of peat of from 1,000 to 3,000 acres each occur in Nepean and Goulbourn, one of them to the east and two to the west of the village of Richmond. It is also found on the third and eighth ranges of Beckwith to the east of Mississippi lake; and an area of about 3,000 acres of peat occurs in Westmeath in the rear of front A, and from the first to the fifth range behind it. In the ninth and tenth ranges of Huntley there are about 2,500 acres of peat; which in some parts has a thickness of eight or ten feet, while in other parts no bottom was found at a depth of fifteen feet. It is probable that peat may be met with in many other localities throughout this region.*

THE HOLLAND RIVER BOG.

Along the Holland river in the counties of Simcoe and York, extending for about eighteen miles upwards from where it empties into lake Simcoe, lies the well-known Holland marsh, containing on a rough estimate about 20,000 acres. It lies on both sides of the river and is of varying width, averaging perhaps one and a half miles. This large tract of country is almost wholly waste land, its only products being bull-frogs and a coarse wiry grass, known as "sea-grass," which is cut in July and August and sold in considerable quantities in Toronto and Hamilton for upholstering purposes. A company was formed in Toronto about twenty-five years ago to acquire the upper portion of the marsh, or that part lying south of the Northern Railway bridge at the town of Bradford, with the object of draining the land and reclaiming it for purposes of cultivation. The scheme was favorably considered by the government of the day, which offered to sell the company the land at the rate of fifty cents an acre; but nothing came of the project, and it is doubtful whether it was a practicable one and whether even if the marshy land were drained it would be suitable for agriculture. A recent visit showed the greater part of the marsh to be a quaking peat bog, in places upwards of nine feet deep, and samples taken from six inches to three feet below the surface proved the peat to be of excellent quality, and to improve with the depth. If any of the processes hereinafter set forth for the manufacture of peat on a commercial scale prove successful, this bog offers notable advantages, being easy of access by way of the Holland river, which is deep enough to float vessels of considerable draft (as it used to do many years ago when it formed part of the highway from Toronto to the northern waters), and also conveniently situated for the transport of the manufactured product to the centres of population, either by rail or boat. Such a process would however require to be one which could dispense with drainage, the marsh being practically on a level with the sluggish Holland, and consequently kept constantly full of water. So long as lake Simcoe maintains its present level, so long is it likely that the Holland peat-bog will remain a "wet" one.

THE BERLIN BOG.

A small peat-bog of about twenty-five acres in extent lies immediately south of the town of Berlin, Waterloo county, from which a quantity of peat has this summer been cut by Mr. Allen Huber, who has been experimenting with it as a fuel for use under steam boilers

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* Geology of Canada, 1863, pp. 780-1.

and for domestic purposes. A trial was recently made of the fuel in the Dominion Button factory of Messrs. J. Y. Shantz & Son, but owing to the peat not having been thoroughly dried the results were not wholly satisfactory, though quite sufficient to warrant the belief that a properly dried article would answer admirably as a source of heat for steam generating purposes. The peat after exposure to the wind and sun for three weeks was found to retain as much as 53 per cent. of moisture. Further tests are to be made by Messrs. Huber and Shantz, whose experiments will be watched with interest. Similar small bogs are said to be common in Waterloo, and doubtless exist in other districts as well. The Berlin bog is underlaid by a thick deposit of shell marl.

OTHER AREAS IN SOUTHERN ONTARIO.

Peat is also found in considerable areas in the townships of Humberstone and Wainfleet on the Welland canal, in which locality it is understood that an attempt is about to be made to utilize the crude material in the manufacture of compressed fuel by the Dickson process, hereinafter described. There are peat-bogs in the vicinity of Stratford in the county of Perth, in Elgin (near Dutton), around lake St. Clair, in parts of Parry Sound district, and large stretches of peat in the muskegs which line the Canadian Pacific Railway west of lake Nipissing and between Port Arthur and Rat Portage. Though the search for peat-bogs has not yet been quickened by a rise in their value as sources of fuel, it is probable that there are few counties in the province where, in larger or smaller extent, they cannot be found.

THE MOOSE RIVER BOGS.

It was long considered that the most extensive peat-bogs in Canada were situated in the island of Anticosti, where a continuous plain covered with peat extends for upwards of eighty miles with an average breadth of two miles, thus giving a superficies of one hundred and sixty square miles. But the explorations of Mr. E. B. Borron in that part of Ontario lying on the Hudson bay slope have led him to the conclusion that in the unexplored wilderness which occupies the basin of the Moose river and its tributaries there are in the territory belonging to Ontario not less than ten thousand square miles overlaid with beds of peat, the depth of which often exceeds six feet, and is probably twenty feet or more in many places.* In this region the conditions for the growth of the *sphagnum* moss are eminently favorable, the flatness of the plains retarding the drainage and the northern climate affording it the necessary lowness of temperature. Accordingly the *sphagnum* flourishes, to the detriment of most other forms of vegetation, and in many parts the surface of the country appears to be wholly covered by beds of peat which are gradually increasing in depth. Here, it may be, are being provided the stores of fuel which shall serve for future generations, if not for our own, when the wood of the older parts of Ontario shall have gone the way of wood in all other countries, or when the coal deposits in the republic to the south shall have begun to fail under the yearly increasing demands upon them. The Nipissing and James Bay railway has been projected into that now inaccessible region, and it is not impossible that part of its southward freight may some day consist of manufactured peat intended for consumption in the furnaces of the manufacturing establishments and in the cooking ranges of our towns and cities. Not until a railway has penetrated to the other side of the height of land will these immense fields of peat be available, but although their value is prospective rather than present it can scarcely be doubted that a time will come when the vast supplies of carbon they contain will be required and made use of.

METHODS OF PREPARING PEAT FOR FUEL.

The question naturally arises why it is that with these abundant stores of raw material and the large demand which would greet a first-class article furnished at a cost less than that of coal, no one has yet succeeded in placing such an article upon the market. Many attempts have been made to do so, for the successful inventor's reward in a coalless country like Ontario would certainly be a golden one, but up to the present the desire end has not been attained. Indeed so formidable have the difficulties proved themselve that the belief is sometimes expressed that the problem is nearly an insoluble one. Th history of the numerous attempts which have been made to produce a first-class articl from the raw material by an economical process, though by no means upholding this view is a record of partial successes only. Probably Prof. N. S. Shaler of the United State Geological Survey takes the gloomiest view of the case of which the circumstances admi when he sums it up as follows:

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*See report of E. B. Borron, Stipendiary Magistrate, Ont. Sess. Papers, 1881, vol. XIII., part IV.

> In New England and Canada repeated efforts have been made to convert peat into more compact and serviceable source of heat by various modes of mechanical treatment None of the methods adopted have proved commercially successful; though the amount o money and mechanical skill devoted to the end has been great, the failure in all cases ha been complete. A similar failure has attended all European efforts having for their object the improvement of peat for fuel. From some studies of the project which I made abou twenty years ago, I came to the conclusion that with ordinary labor at $1.50 per diem i would be possible to make serviceable fuel at the cost of about $5 per ton. The difficult however is not altogether found in the cost of the treatment of the peat or in the natur of the product, at least as far as the production of heat is concerned, but in the popula prejudice against some of the qualities of the fuel. Peat is generally very ashy, it has peculiar odor, and the fire made from it is not lasting. It is impossible in this report t give a review concerning the history of peat fuel; such a review would however sho that the prospect for utilizing this material in the United States is very small.*

It is doubtless true that in the United States where coal is plentiful and cheap th introduction of a new article of fuel does not possess the same degree of importance as i Ontario where coal does not exist and where it is of necessity dear; and it may be safel asserted that the amount of "popular prejudice" which a really good peat fuel woul have to overcome in Ontario would be very small indeed. Such an article would b received on its merits, and if it successfully stood the test of every-day use would rapidl come into general employment. The fact that some of the largest consumers of coal i Canada, notably the Grand Trunk and Canadian Pacific Railway companies, details o whose tests are given below, have experimented with peat in the hope of finding a efficient and economical fuel which they would be warranted in adopting shows that hearty recognition awaits the inventive skill of the man who shall place such a fuel at th service of the public.

It may be conceded that if we could hope to have no better fuel than air-drie peat produced from the raw material in the ordinary way, valuable as this is, the likelihoo of its ever taking the place of coal to any appreciable degree would be remote, but experience has shown that it is quite practicable to obtain a first-class fuel by means of a numbe of known processes more or less differing from one another. The difficulty with them a has been very largely one of cost. It has not hitherto seemed practicable to expel th water from the raw peat and reduce it to a sufficient degree of density without incurrin an expense which precluded the possibility of its competing with coal. The fault, a Prof. Shaler himself admits, has not been so much with the quality of the fuel, and inde much evidence can be adduced testifying to the good properties and high calorific valu of the manufactured article.

ESSENTIAL OPERATIONS IN MANUFACTURE.

Sir Robert Kane, who in his "Industrial Resources of Ireland" and elsewhere ha given much information on the subject of peat in that country, states that the averag result of a great number of experiments made in Irish bogs show that the general mas of the undrained peat, including both the lighter and the denser varieties, contains fro 92 to 95 per cent. of water, while the edges of the bog and parts more or less drained, i the state in which peat is usually cut, contain from 88 to 91 per cent. The turf, as use in that country often holds from 20 to 35 per cent. of water, while that which has bee stacked from six to twelve months still retains from 18 to 20 per cent., and that whic has been kept in a dry house for two years, from 10 to 15 per cent. of water. Air-dried uncompressed peat is a very bulky fuel, its specific gravity being about .85 while that of coal is from 1.25 to 1.39. The essential operations, then, in the manufacture of condensed peat are, first, to get rid of the water and, second, to reduce the material to a density more nearly resembling that of coal.

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* Fresh-Water Morasses of the United States, by Nathaniel Southgate Shaler, Tenth Annual Repo U. S. Geological Survey, pp. 303-4.

Details of processes by which these ends have been sought to be accomplished, are given by Logan in the Geology of Canada (1863), and by many other writers on the subject.

VARIOUS PROCESSES REVIEWED.

The process patented by Linning in 1837, and used at Ekman's iron works in Sweden has been followed substantially by many other experimenters. The peat is first ground to a homogeneous mass in a pug-mill, similar to that used by brick-makers, afterwards moulded into convenient shapes and consolidated by a hydraulic or other press, after which the blocks are dried by artificial heat. An excellent fuel is the result. This is substantially the method adopted by Weber, of Staltach, in Southern Bavaria, by Gysser, of Freiburg, who invented a portable hand-machine to bring the operation within the reach of persons of limited means and dried his blocks in the air only, by Schlickeysen, who also dispensed with artificial heat for drying, and by numerous other inventors on the continent of Europe. The common feature of these processes is the grinding or triturating of the peat into a pasty mass, the end being to reduce it in bulk. Charcoal prepared from peat manufactured in this way is said to be much firmer, more compact and better suited for heating purposes than that made from either air-dried peat, or peat which has been subjected to compression only.

Williams' plan at Cappogue, Ireland, was to place the ground peat between cloths and subject it to a powerful hydraulic press. By this means he succeeded in reducing it to one-half its original weight, and one-third its volume. The remaining water was, however, difficult to be expelled from the consolidated peat, and the more fibrous varieties expanded a good deal in drying.

This experiment was afterwards repeated on a considerable scale by the Irish Peat Company, and with similar results. They also built large drying-houses in which attempts were made to dry ordinary peat by artificial heat, but the quantity of fuel required to expel the great amount of water from the peat was found to be so considerable that the process was not economical.

A plan followed at Rosenheim, in southern Bavaria, is, after drying the peat in the ordinary manner, to pulverize it by passing it through rollers, then to drive off the remaining water by heat and consolidate the dry powder by powerful pressure. The peat is made into small blocks of eight to ten ounces, weighing from 70 to 80 pounds per cubic foot, which corresponds to a specific gravity of 1.25, or nearly that of bituminous coal.

Hodgson of Ireland adopted a plan for securing a cheap and abundant supply of dried and powdered peat by passing a very light harrow over the surface of the bog and thus breaking up a thin layer. After a few hours exposure to the air, for draining and partial drying, this is removed by scraping, and a supply of powdered peat much drier than the general mass may thus be obtained. It is then heaped in embankments and dried by being spread on iron plates warmed by the waste steam from the compressing engine. The pressing machine consists of "a horizontal reciprocating ram," said to be capable of turning out 1,500 lb. of compressed peat per hour equal in density to coal.

The process patented by Gwynne & Co., differs from Hodgson's in depriving the raw peat of a large part of its moisture by subjecting it to the action of a centrifugal machine, after which it is ground to powder and passed through a series of cylinders revolving in a heated chamber, where the remaining moisture is got rid of. It is then compressed at a temperature of 180°, at which temperature the tarry properties of the turf are just sufficiently developed to form a good cementing compound, and the result is a dense and very pure fuel.

In 1856, Exter, of Bavaria, carried into operation on an extensive scale under the Bavarian government a method of preparing peat fuel which in its initial stages is practically identical with Hodgson's, described above. After scraping together the broken and partially dry peat it is, if necessary, further pulverized by passing it through toothed rollers. It is then introduced into a complicated drying oven, along the various floors or chambers of which it is moved by spiral conveyors exposed to a temperature of from 120° to 140° Fahr. The peat is then subjected to the action of a powerful eccentric press and formed into blocks which occupy about one-fourth the space of the same weight before pressing, the cubic foot weighing about 72 lb. In 1857 the cost of peat produced in this way was estimated at about 6 cents per 100 lbs., and was of excellent quality, being used exclusively for firing locomotives. Exter's process was adopted with some modifications in Hungary and Hanover, in the latter country unsuccessfully, owing to the fact that it is suited only to the better kinds of peat.

Elsberg, of New York, invented a modification of Exter's method by which the peat, air-dried as in Exter's process, is further broken in a cylindrical pug-mill and at the same time subjected to a current of steam admitted through a pipe and jacket surrounding the cylinder. The steamed peat is then condensed by a pair of presses fed directly from the mill. In this way the complicated drying oven of Exter is dispensed with.*

THE DE BRUGHAT METHOD.

The Dublin University Magazine for October, 1873, states that during the previous year (1872)—

> A commission was organized under the auspices of Alderman Purdon, of Dublin, for the purpose 'of investigating in the public interest by personal examination, such of the best modern systems of preparing improved fuel from peat as are now to be found elsewhere.' With this view the commission visited several of the chief localities on the continent where the manufacture of peat fuel is carried on, and found various methods of manufacture at work, but they say that 'the principle in all is the same; the raw peat is subjected to a pulping process indispensable for the production of density, without the aid of any mechanical compression.' . . . . . In reporting the result of their investigation however they declare that 'in the application of the principle of macerating raw peat and in the air drying process will be found the only reasonable system of producing dense turf upon a commercial basis, and then they go on to recommend that owing to our variable and humid climate the manufacture would be greatly facilitated by the erection of drying sheds.†

The University Magazine claims for M. Challeton de Brughat, a French gentleman, the honor of having invented this process, which it describes as one in which thoroughly decomposed peat is well puddled together with a due admixture of water and then passed through a very fine sieve, which separates the minute carbonaceous particles; these when submitted to a process of drying are found to possess an adhesive affinity the effect of which is to combine them together in one solid mass analagous in density and hardness to ordinary coal.

De Brughat first brought his invention under public notice at the Paris Exhibition of 1855, and again in 1867, on both occasions receiving prize medals. A modification of his method was adopted by the Irish Peat Fuel Company as follows: The raw peat after having been properly macerated in a powerful disintegrating mill, cleansed from impurities and reduced to pulp, is conducted into reservoirs 160 feet long by 42 feet wide and 18 inches high. The sides of these reservoirs are made of a kind of basket work, and the water in which the peat particles are held in suspension flows rapidly away on all sides, acted on by the force of subsidence. When the pulp has acquired sufficient consistency its surface is marked out by a cutter into regular brick-like shapes, which facilitates the process of drying so much that in twenty-four hours afterwards they are generally dry and firm enough to bear handling. They are then removed and placed on light frames where they remain for a month, when they are completely dry and ready for delivery.

In May, 1873, a quantity of de Brughat's peat-coal was tested on the North London Railway, England, a trial run being made from Broad-street station to Kew, a distance of 29 train miles, with a train consisting of an engine and nine carriages. The results gave

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*See Peat and its Uses, by Samuel W. Johnson, A.M., Professor of Analytical and Agricultural Chemistry, Yale College, p. 121 *et seq.*

†Dublin University Magazine, vol. LXXXII. p. 388.

the highest satisfaction. The steam was abundant and the engine worked up to 165 lb. pressure. The consumption of fuel for the total run was 48.3 lb. per mile, leaving off with a large, clear fire; there was no clinker in the bars and but a small amount of debris in the smoke box. The average consumption of the best coal by the Kew and Richmond passenger train for the same number of carriages is 32 lb. per mile.

One and a quarter tons of de Brughat's peat-coal are said to be equal to one ton of the best English coal for ordinary steam purposes, while for household use and for furnaces having little draft and with the fire bars close together one ton of peat coal is equal to the same quantity of pit coal.

As to the commercial aspect, it is stated that de Brughat's own manufacturing experience, extending over many years, proved beyond a doubt the remunerative character of manufacturing peat-coal. The total cost of producing this article on a large scale at de Brughat's works is 6 shillings per ton, while he gets for it on the spot 28 shillings per ton and from 33 shillings 6 pence to 36 shillings per ton at Paris, at which price the demand is active for all he can supply. The same gentleman also manufactures peat charcoal at a profit of 300 per cent. in actual operations. The charcoal is stated to cost practically nothing to manufacture, owing to the value of the other products evolved in the process; and it sells at £6 to £6 8s. per ton in Paris, wood charcoal bringing between £5 and £6 per ton.

The foregoing statements are all taken from the article in the Dublin University Magazine above mentioned, and if they even approach the truth they establish beyond a doubt that the manufacture of peat fuel can be conducted on a commercial basis.

THE CLAYTON METHOD.

In Ure's Dictionary of Arts, Manufactures and Mines (1875) it is alleged that for practical purposes peat as prepared in Ireland in the ordinary way is absolutely spoiled. One pound of pure dry turf will evaporate six pounds of water; now, in one pound of turf as usually found there are three-quarters of a pound of dry turf and one-quarter of a pound of water. The three quarters of a pound can only evaporate 4½ pounds of water, but out of this it must first evaporate the quarter pound contained in its mass, and hence the water boiled away by such turf is reduced to 4¼ pounds. The loss is here 30 per cent., a proportion which makes all the difference between a good fuel and one almost unfit for use. When turf is dried under cover it still retains one-tenth of its weight of water, which reduces its calorific power 12 per cent., one pound of such turf evaporating 5¼ pounds of water. This effect is sufficient however for the great majority of objects; the further desiccation is too expensive and too troublesome to be used except in special cases. The same authority gives the following account of the Clayton system of preparing peat, which it will be seen is similar in some respects to the de Brughat plan already described.

The Clayton method is simply to cut the peat into fragments in its raw, moist state, drain off as much of the water as will freely run away; then masticate the fibres and whole mass of peat together in a machine until it becomes difficult to distinguish any ligneous fibre distinct from the humus in which it is so entirely mixed. The pulped peat is forced out through orifices in the end of a cylinder on to rollers which carry it to trays where it is cut into lengths and then taken to the drying-sheds, where it remains about three days; it is then dry enough to be stacked in open racks where the final drying is completed. The most important feature in this system is the breaking up of the cellular tissues of the peat and thus getting rid of the fixed moisture: and the remarkable reduction in the size of the blocks of peat during the process of drying shows that this is done in the most complete manner. The condensed peat becomes very firm and solid, and the whole process does not take more than seven or eight days. Messrs. Clayton, Son and Howlett assert that this fuel can be produced at a cost of from five to six shillings per ton.

A EUROPEAN METHOD.

The article further states that an idea of what is being done on the continent of Europe may be obtained from the following account of a method of condensing peat:

The peat press consists of a wooden tub about six feet high and two feet wide, chained upon a kind of sledge. The wooden vessel contains an upright shaft which may be set in motion by means of a horse-gear. This shaft carries on the bottom an iron disk, above it two revolutions or turns of screw blades and above these four similar blades, each forming a quadrant and so arranged that they form a complete revolution. Knife-like projections in the wooden vessel prevent the peat revolving with the blades and shaft. The opening for the introduction of the peat is at the back on top; in front is the iron delivery which may be opened by means of a lever, and contains a wooden conical mould through which the peat issues in four endless strings or streams on an inclined table, on which it is cut in pieces or blocks of convenient length. These are then dried in the open air. The peat having gone through this machine dries much more quickly and burns with greater intensity of heat, and the lightest and poorest stuff so worked is fitted for consumption under steam boilers. One volume of this pressed peat is equal to two of Hanover peat, or to three of ordinary cut peat, and the intensity of heat developed stands in the same proportion.*

OTHER METHODS OF TREATMENT.

The same authority describes other methods of treatment as follows:

Danchelle's peat-fuel and peat-filters for sewage were exhibited at Manchester in 1874. The samples of manufactured peat-fuel made from the light brown moss of Red Moss, Horwich, Lancashire, differed from other specimens of peat-fuel in that the humus and ligneous fibre of the peat were macerated and reduced to a state of a fine chocolate-paste. The machine used to effect this consists of a long cylinder, in which works a shaft armed with proper cutters and disks, by which the crude peat is soon reduced to the consistency of pasty pulp, and issues in a long roll of any shape or diameter; this is cut into briquettes by a wired frame, and the briquettes are dried in the usual way, under a covered shed; in drying they lose in their bulk, but they are in a fortnight converted into a good hard fine-grained fuel, and when roasted with charcoal are about one-third their original size. The producers of the Danchelle peat-fuel also convert the peat into sewage-filters by incorporating the peat with a mixture of clay and charring them. Experiments have been made and are continued with these filters in Bradford, Yorkshire, and in Paris, and the results are stated to be very satisfactory. Peat-fuels are prepared in Sutherland by charring the peat, which has been broken up by a machine, so as to leave it in a rough granular state, and afterwards worked up with crude shale-tar, and pressed into bricks by a moulding machine. The quantity of shale-tar taken up by the vegetable peat is very considerable, and gives it a thoroughly carbonized appearance.

Mr. Robert Kerretichison breaks up his peat with a machine, by means of which it parts with a great deal of its water. It is then manufactured in a masticator, and finely-broken asphalt is mixed with the mass. It is then shaped into briquettes and dried under sheds. Its specific weight is less than most other peats, and the addition of asphalt adds to its cost, but gives it greater value for furnaces and for raising steam.†

In Austria and some parts of Germany, a process obtains of grinding the peat as rags are ground in a paper mill, by the addition of water, to a very fine pulp, which is placed in suitable receptacles, and by filtration and evaporation relieved of most of the water. It is then cut into blocks and stacked away for use at a later day. The product is said to be excellent, but the process is slow and expensive.

The treatment adopted at Horwich, Lancashire, England, presents some points of difference from any of the foregoing. The peat is pulped in a mill arranged for the purpose, and conveyed by means of an endless band to a moulding machine, which cuts it into blocks of any required size. The blocks then travel backwards and forwards in a drying chamber on moving bands exposed all the time to a current of heated air. The product is said to be hard, dense and of excellent quality.

The apparatus invented by Mr. Buckland of South Wales consists of a solid, obtuse iron cone, having a spiral groove on its exterior, and revolving vertically within a hollow cone of iron plate, perforated everywhere with small round holes like a colender. The peat is put into the space between the solid and hollow cones and by the revolution of the former is forced in worm-like form through the holes in the latter. It is then fashioned into bricks by any convenient machine, and artificially dried. This process is said to produce a good quality of fuel, but to be of small capacity and expensive to work.

Other methods of treatment on the continent of Europe consist in passing the crude peat in its moist state through rollers which reduce it in bulk, and deliver it in soft blocks or sheets, which are afterwards removed to spreading-grounds or sheds to be dried;

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* Ure's Dictionary of Arts, Manufactures and Mines (1875), Vol. III. p. 526.

† *Ibid.*, p. 527.

or in pulping the raw peat with the addition of considerable water, and dividing it in this state into moist blocks which are dried in kilns or the open air.

PROCESSES TRIED IN THE UNITED STATES.

The attempts to convert raw peat into a serviceable fuel have been fewer in the United States of America than in Europe, largely, no doubt, because of the comparative cheapness and abundance of wood and coal in the former country. Nevertheless, the problem has been attacked by a number of experimenters, some of whom have been content to follow European processes, while others have invented plans of their own. It was thought by some of them that the peat as it was taken from the bog could be wholly freed from water by compression, and presses of great power were brought to bear upon it with this belief. Experience showed however that a considerable percentage of the moisture is retained by the peat with such tenacity as not to be amenable to pressure only.

Under the patents of Ashcroft and Betteley operations were carried on at Lexington, Mass., for several years subsequently to 1864. Their process consisted in reducing the raw peat to a pulp, which was then conveyed into high tanks where it was allowed to remain until of its own weight and pressure it became sufficiently dense to be formed into blocks, when small gates were opened at the bottom of the tanks, and the superincumbent mass forced the peat out in a continuous sheet of uniform size. This was cut into blocks which were laid away to dry. Experiments were also made with the view of drying peat by absorption, the plan being to cover the spreading-ground with a layer or pavement of porous brick, on which the soft pulp was laid as it came from the machine. No great measure of success seems to have been achieved by either of these methods.

By a machine set up at Pekin, N.Y., in 1865, the invention of M. S. Roberts, the peat was ground to a pulp with water to the consistency of mortar, and then, by means of a long conveyer attached to the machine, spread on the ground and cut into blocks, which were left to solidify and dry in the open air.

THE LEAVITT PROCESS.

In the process patented by T. H. Leavitt of Boston, Mass., the apparatus consists principally of a strong box 3 feet square and 6 feet high, supported upon a stout framework about 4 feet above the floor of a suitable building, which should be near the bog, and is best constructed on a side hill, so that easy access can be had to the lower story on one side from the foot of the hill and to the second story on the other side. The top of the tank should be open, and even with the floor of the second story, so that the raw peat can be dumped directly into it. Within the tank, and firmly fixed to its sides, are numerous projections of a variety of forms, adapted to the treatment of the material in its several stages as it passes through the mill, which is divided into three apartments. Through the centre of the tank revolves an upright, to which are affixed knives and arms varying in form and structure to correspond to the stationary projections in each apartment; below the tank is a receiver or hopper, and under this is a moulding or forming machine, 2 feet wide and 12 feet long, of simple construction, which receives the condensed material from the hopper and delivers it in blocks of any desired form and size, to be afterwards laid out upon the ground or on frames to dry. The whole is adapted to be driven by a small steam engine, and requires about six and ten horse power respectively for the two sizes of machines constructed, of the capacity of 50 and 100 tons each of crude peat per day of ten hours. It is claimed for this treatment that it entirely destroys the original organization of the peat and expels the air from its cells, thus allowing the water to evaporate so freely that at the end of eight or ten days the peat is in a condition to be housed or transported to market. Figures are given by the inventor to show that in 1867, with ordinary labor at $1.75 per day, twenty-five tons of merchantable fuel could be prepared per day at an outlay for wages of $37.75, the cost of the apparatus itself being $4,500. The product was said to weigh from 65 to 80 pounds per cubic foot, which is equal to a specific gravity of from 1.04 to 1.28.

THE WALKER MACHINE.

Another machine is that of Thomas George Walker, which both grinds and artificially dries the material. The wet peat, after being puddled in a pug-mill vat and heated by waste steam, is forced through the bottom into a box, whence it is blown by a steam jet through 400 feet of 6-inch cast iron pipe, coiled up in the furnace under the boiler, by which means it is thoroughly dried. It then passes through a larger pipe into a receiver, at the bottom of which it falls into a mould, where it is pressed into form by a plunger. The residual steam and gases pass from the top of this receiver in a tank through another pipe whose end is under water, in which any dust carried off by the steam is deposited ; and the waste steam and gases thus purified pass thence back to the pug-mill jacket, where they are used to heat the new material. A second tank, under the pug mill, receives the water from the waste steam condensed in the jacket, and all combustible gases rising to the top are conveyed through a pipe to the furnace and utilized as fuel. The successive heating of the peat in the pug-mill vat and in the long passage through the 6-inch pipe so prepares it that it is easily moulded into a compact form as it leaves the receiver.

CANADIAN METHODS OF TREATMENT.

The utilization of the great peat deposits of Canada is no new project, and at various times during the last thirty years there have been brought to public notice processes which were claimed to have brought the production of a first-class peat fuel at a sufficiently low cost well within the domain of fact.

THE HODGES SYSTEM.

The Hodges system of peat manufacture, described by Sterry Hunt in the report of the Geological Survey of Canada for 1866, was deemed by that eminent scientist to be a very promising one and likely to lead to the development and utilization of the supply of peat in Canada. It consisted in a manufactory which should float about in the bog, cutting its own channel, excavating and pulping the peat and finally spreading it out to dry ; the whole without manual labor. The peat after all sticks and roots were removed was passed through machinery which destroyed its fibre and reduced it to a homogeneous mass of soft pulp like well-tempered mortar. This was then spouted out to the surface of the bog, previously levelled and prepared for its reception, and spread in the form of a thin sheet nine inches in thickness and ninety feet in width. After lying a couple of days it began to consolidate and was then divided by transverse cuts at intervals of six inches. In a few days more it was divided longitudinally, and in about a fortnight the shrinking of the peat caused the cuts to open, and gave the whole bed the appearance of an immense floor covered with bricks eighteen inches long by six inches wide. As soon as these were sufficiently hard for handling they were taken up and stacked for drying.

The manufacture of peat after this process was carried on by Mr. Hodges at Bulstrode on the Three Rivers and Arthabaska railway. Fifty tons of the air-dried peat fuel could be produced in a day of ten hours, costing, when dried and put into barges on the canal, according to Dr. Hunt, ninety-two cents per ton. As thus prepared it contained about twenty-five per cent. of water, the greater part of which was lost by further drying. Numerous experiments were made with peat prepared after the Hodges plan as a fuel for locomotives on the Grand Trunk railway with "signal success." To quote from the report :

> A subsequent trial with an express train from Montreal to Kingston, 177 miles, showed that one ton of 2,240 pounds of peat holding 20 per cent. of water was consumed in running 50½ miles, being equal to 44.5 pounds of peat to the mile. With Pictou coal on the Boston and Worcester Railway, for the month of August 1856, the average distance run was 59.9 miles per ton of coal, being equal to 37.3 pounds of bituminious coal to the mile. Peat is found to require for its combustion in the fire-box of a locomotive little or no blast, the production of which, for wood or coke, involves a great expenditure of steam power ; and it is supposed that by altering the blast to suit the requirements of peat a great economy in the use of this fuel may be attained. It is also found that in burning it even with the present great blast, no sparks are produced, so that the use of peat affords a guarantee against the frequent fires arising from the sparks of engines burning wood. . . . In one

experiment, the minutes of which are before me, an engine with a train of twelve loaded cars on the Grand Trunk Railway consumed in running 44 miles 2,440 pounds of peat, equal to about 40.3 miles to the ton or 55.5 pounds of peat to the mile. In doing this 1,900 gallons of water are said to have been evaporated. If we take these to be American standard gallons this gives 6.48 pounds, and if imperial gallons not less than 7.78 pounds of water evaporated for each pound of fuel consumed.*

It seems probable that Dr. Hunt underestimated the cost of producing this peat fuel, or that further trial did not confirm his account of its heat-producing qualities, as in the quarter of a century which has elapsed since he made his report the Hodges system has not come into vogue, and the problem of producing a cheap and efficient peat fuel has yet to be solved.

THE AIKMAN PLAN.

The process invented and patented by Mr. David Aikman of Montreal, is thus described by Mr. Aikman himself, in the specification forming part of letters patent granted him by the United States patent office on 2nd October, 1888 :

> In manufacturing my improved fuel I prefer to take the peat in a semi-liquid or pulpy state and after removing the sticks by any of the well-known devices, evaporate and remove the surplus water by stirring the pulp in a steam-heated vessel or chamber, and then complete the drying process by passing the peat through heated rollers or between rollers and heated plates. This liberates the lighter volatile vapors and leaves the peat in small flakes or particles ; but while undergoing the above operation the carbon-cells are only partly broken, and in order to finish what may be called the "fracture" of the cells and saturate the free carbon again with the highly inflammable tarry and resinous substances, and bind the same permanently together in a solid compact mass having the qualities above specified, I direct the peat thus dried and prepared into moulds kept at a high temperature by the direct application of fire, or by using superheated steam, and there reduce the same to a charred or carbonized condition. While this carbonizing is going on the peat is kept under heavy pressure in the moulds by plungers or like devices (also brought to a highly-heated condition) until the fibrous or vegetable matter and the volatile elments are thoroughly incorporated together, and the exterior of the block is coated with the resinious matter and glazed by the friction and heat and thus rendered water and air proof.

Practical difficulties in the way of constructing suitable compressing apparatus have it is said retarded the manufacture of peat by the Aikman process on a commercial scale, but sufficient quantities have been produced to prove that a satisfactory fuel can be made in this way. A test of Aikman's peat fuel as compared with Sydney soft coal was made under a stationary boiler in the locomotive shops of the Canadian Pacific Railway Company, Montreal, in 1887, under the direction of Mr. Francis R. F. Brown, mechanical superintendent. In his report to the company Mr. Brown says :

> As we did not go to any expense in getting up a special grate of a wood-burning class for testing the peat and as the test was made on a coal-burning grate, we may consider the results obtained from the peat as satisfactory. The temperature and state of the atmosphere were also in favor of the coal. I am satisfied that with a suitably arranged grate a much better result would have been obtained, but even leaving the grate as used for coal burning providing we could obtain the peat at $2.25 per ton it would still be a saving over coal. This peat fuel has proved itself superior to the best wood, and the difference in wear and tear on a locomotive fire-box between wood and coal is too well-known for me to dilate on. . . . . . The test was conducted in one of the Lancashire boilers, and commenced each day about 8 a.m., and a little irregularity occurred in consequence of the coal test extending over the dinner hour from 12 noon to 1 p.m. . . . . . The coal-grate was shortened about one-third to prevent any loss of steam by blowing off, due to the great amount of flame produced by the peat. Some peat also fell through the bars partly consumed, and though no opportunity offers to ascertain still it is probable that some was carried into the flues by the draught. The firing was light and the damper well down when the peat was tested, which explains the difference of water evaporated per hour, that being in no way to be attributed to the kind of fuel. I have no doubt that if tested under more favorable conditions, and when better acquainted with the class of fuel, the peat would give a relative efficiency of 75 per cent. as compared with the same class of coal as used, which was of good quality, being Sydney. Taking the coal as costing $3.50 per ton in the works, the peat (at 68 per cent.) would be worth $2.38 per ton delivered here.

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* Geological Survey of Canada, 1866, pp. 289-90.

Following is the result of the test:

Description.	Coal. Sydney, soft.	Peat. West Farnham compressed; brown, soft.
Date of test	September 5th, 1887	October 13th, 1887.
Weather	Warm; fine	Wet; dull.
Duration of test	5 hours, 45 minutes	3 hours, 20 minutes.
Total fuel burned	3,360 pounds	2,625 pounds.
" water evaporated	25,900 pounds	12,610 pounds.
Average steam pressure	66.3 pounds	64.6 pounds.
Temperature of feed water	66° Fahrenheit	55° Fahrenheit.
Water evaporated per pound	7.07 pounds	4.8 pounds.
do comparative from and at 212°	8.35 pounds	5.7 pounds.
Relative efficiency	100	68.

An objection to the use of this fuel for locomotives is its tendency to disintegrate on being exposed to the weather. For domestic purposes however this objection did not apply, and Mr. Brown, who used it in his own house for some weeks continously, speaks very highly of its qualities as a domestic fuel, being easy to kindle, lasting a long time, giving out a great heat, cleanly to handle and leaving very little ash. A chemical analysis gave the following as the composition of a sample of the fuel:

Moisture	3.84
Volatile combustibles	41.22
Fixed carbon	48.04
Ash	6.90
Total	100.00

In view of the excellent character given the Aikman fuel it is to be hoped that the attempts now being made to overcome the mechanical difficulties in its manufacture may be successful.

FEATURES OF THE DICKSON PROCESS.

A method of preparing condensed peat fuel which has recently been invented by Mr. A. A. Dickson of Montreal contains some new features, and seems likely to lead to important results.

In Mr. Dickson's process the peat is cut direct from the bog or bed and elevated by carriers consisting of buckets attached to an endless chain, and discharged into a hopper from which it is fed automatically through a novel three-roller pressing mill having hollow cylinders of perforated metal or wooden slats covered with felt cloth about 1½ inches in thickness, which extracts the greater proportion of the moisture and delivers the peat in a semi-dry and spongy state, its fibrous nature not being destroyed or the component parts ground or pulverised as is the case under most other processes. The peat is then lifted into a revolving cylinder constructed of boiler plate, having upon its inside longitudinal shelves of plate and hung with the axle of the intake end about six inches higher than the axle of the outlet end. This cylinder is kept at a temperature of about 420° to 450°F. by exhaust heat of the boiler furnace delivered through a pipe, and with each revolution the peat is tossed and carried forward through the hot chamber to the outlet. Thence it is taken by carriers and delivered to another revolving drier which consists of a series of cylinders one arranged within the other, each being the frustrum of a cone connected by openings at the ends, and as the larger diameter is at the farther end the peat is carried forward from one cylinder to another by a steady progressive movement towards the outlet with every revolution. Hot air is supplied in the same way as to the first cylinder, and when the now practically dry peat is finally discharged through a shoot it is taken up by an endless chain carrier and conveyed to a compressing machine where it is subjected to a pressure of about ten thousand pounds to the square inch, formed into the shape desired, and is then ready for market.

The felt rollers expel about 60 per cent. of the water contained in the peat as it comes from the bog; of the remaining 40 per cent., 30 is driven off by the heated cylinders, and 10 per cent. is retained in the finished article, Mr. Dickson stating that he finds it preferable to allow the fuel to contain this proportion of moisture.

The effect of the pressure is said to be to bring the oily and tarry constituents of the peat to the surface of the block, thus giving it a coat of inflammable material which makes the fuel readily ignitible and at the same time renders it impermeable to moisture. The size of the blocks is preferably about three inches long and three inches in diameter, each block weighing about a pound.

The process is automatic throughout, the material being taken from the bog and carried through each successive operation without handling or interruption. As a consequence the manufacture proceeds very rapidly, and the raw peat is converted into dry, condensed fuel in twenty minutes from the time it is lifted from the bog. This, at any rate, is what the inventor hopes to achieve by his apparatus, which has not yet been constructed upon a commercial scale. A working model has been erected at Montreal capable of turning out 400 or 500 lb. per day, which the inventor states works most satisfactorily and has met his expectations in every way.

A full set of machinery, exclusive of motor power, will cost about $6,000, which would be capable of producing 50 tons of manufactured fuel per day of twenty-four hours at a total cost of $75, or $1.50 per ton, the labor of eight men being required. An engine of 40 horse power keeps the machinery in motion, and with boiler to correspond brings the whole cost of the plant up to about $10,000.

The machinery is placed on board a scow which floats on the bog, and being wholly under cover can be worked in winter as well as in summer.

The fuel made by the Dickson process has been tested with good results. In April of the present year a quantity was tried at the works of the Toronto Street Railway Company by Mr. Jackson Pollock, who gives the following account of the experiment:

> The fire was raked out clean off the grate bars, and a new fire started with shavings the steam standing at 60 lb. The first of the peat was thrown on at 3.05 p.m., 487 lb. in all being used for the test. The pressure rose to 80 lb. and remained stationary at 80 lb. until 4.50 p.m., one hour and three quarters, when it fell away to 60 lb. I then threw in coal upon the balance of the peat remaining on the grate. The steam was very steady and we were using all our power. No smoke was to be seen from the chimney, and there were no clinkers or cinders to clean out of the fire. The boiler tubes were dirty; I left them so purposely to give the fuel as hard a test as possible. The peat was not as solidly compressed as sample, and as you describe it it should show still better results. The average daily consumption of coal for six months ending January 31st was 2,074 lb.

An analysis of a sample of Dickson peat showed it to be composed as follows:

Moisture	8.55
Volatile combustible matter	56.34
Fixed carbon	31.04
Ash	4.07
Total	100.00

A small quantity of this peat was submitted by the Bureau to Prof. W. H. Ellis, of the School of Practical Science, Toronto, for the purpose of having a test made of its calorific value as compared with that of coal. Following is Prof. Ellis' report, dated 16th June, 1892:

> I send herewith the results of my examination of the compressed peat you sent me. The sample contains 10.2 per cent. moisture and 2.9 per cent. ash. It gives in Thompson's calorimeter a heating power of 5,280 metric heat units; that is, one gramme of it will raise 5280 grammes of water one degree centigrade.
>
> The samples of coal you sent me gave when tested in the same instrument: No. 1, 7,425; No. 2, 6,820; No. 3, 7,480; mean of the three, 7,241.

Coal sample No. 1 was Massillon coal from Ohio; No. 2, Hocking coal from Ohio, and No. 3, Reynoldsville coal, from Jefferson county, Pennsylvania. They are all bituminous varieties. Mr. Elias Rogers, Toronto, from whom the samples were obtained, says as regards their qualities: "The Massillon coal is a superior coal for grate purposes; the Hocking coal is fair coal for grate purposes and fair coal for steam; the Reynoldsvill coal has the control of this market for steam purposes. The average price of Reynoldsville delivered would be about $4.25 per ton, although for large factories where it is a convenient delivery less prices are made."

It will be seen that the heating power of the sample of Dickson peat was very nearly three-fourths of the average of these well-known brands of coal.

The superiority of the fuel manufactured by this process over that produced by nearly all others lies, according to the inventor, in the fact that the original fibre of the peat is retained intact, and with it the whole of the tarry and oily constituents as well as the gases contained in the peat, all of which are valuable factors in the calorific power of the fuel. The retention of the fibrous condition is also an aid in the rapid drying of the peat. The trituration and grinding of the raw material characteristic of most of the older processes has the effect, it is alleged, of liberating a large proportion of the gases, which are thus wholly lost. In addition to this the finely divided pasty condition to which the peat is reduced in these processes renders it so tenacious of moisture that it can only be dried by applying sufficient heat to cause partial carbonisation, during which process a further loss of the tarry and volatile combuscible constituents occurs.

Mr. Dickson has patented his invention in Canada, the United States, Great Britain and France, and is at present engaged in forming a company for the manufacture of his fuel in this province.

TESTS OF PEAT FOR FUEL.

Many experiments have been made in various parts of the world with peat, both in an air-dried and a compressed condition, as a fuel under the boilers of railway locomotives and steamship engines. It is in regular use on the railways of some of the continental countries of Europe, for example, Bavaria, Oldenburg and Russia.

It does not appear however to be coming rapidly into favor for this purpose, one serious defect being that except in the best samples of condensed peat much more space is required for stowing it than for an equivalent quantity of coal. For the same reason the cost of handling is greater and more time is needed for renewing stocks of fuel.

Time and space are everything on board railway trains and steamboats, and so long as coal does not rise materially in price above its present figure it is unlikely that peat will usurp its place in the bunkers of the steamboat or the tender of the locomotive.

Another objection to its use on railways is the fact that most of the varieties of peat hitherto manufactured crumble more or less upon exposure to the weather.

On the other hand, the use of peat is much less detrimental to grate bars and furnaces than that of coal, and there is an absence of cinders, clinkers, and to a great degree of smoke.

In 1881, 60,885 tons of peat turf were used on railways in Russia; in 1891 the quantity had fallen to 51,678 tons.

Records of various Trials.

There is not space here to quote the details of the numerous trials made with peat as a railway and steamship fuel; some of them have not been satisfactory, but many go to show that even for this use, for which it is perhaps not so well suited as for domestic purposes and generating steam in stationary boilers, while not so valuable as coal it nevertheless constitutes an important resource which some day is likely to be taken advantage of. A few examples of the use of peat in this way may be given, and the records of some tests made in Canada may be of interest and value.

As early as 1844, Sir Robert Kane informs us, steamers plying between Limerick, Clare and Kilrush in Ireland were using peat for fuel. The "Garry Owen" steamer made the passage between Clare and Limerick (distance about 45 miles) fired with turf in 3 hours 20 minutes.

Still earlier Professor Emmons in a report to W. H. Seward, Governor of New York, in 1839, speaks of some experiments with peat as a fuel for steam engines in which a small quantity of tar was mixed for the purpose of creating a larger volume of flame, and says: "The experiments referred to were made on board the 'Great Western' during her last passage, and such was the result that a large amount of peat was taken on board for her homeward passage."

The locomotive engineer of the Belfast and Northern Counties Railway had tried the condensed peat on that line. In a trip of 74 miles the total quantity of fuel burned was [illegible] cwt., 1 quarter, 14 lb.—the train, including engine and tender weighing 70 tons. The time occupied was three hours, nine minutes. The trial proved satisfactory. . . . . . The locomotive superintendents of three railways in Ireland made a trial of condensed peat on the same railway to test its fitness for locomotives. During a trip of 27 miles there was an excess of steam though the fire door was continually open and the damper down for the greater part of the distance. The pressure at starting was 100 lb. The commencement of the trip was up an incline of 1 in 80, four miles long, with double curves. While ascending this incline the pressure rose to 110 lb. and afterwards to 120 lb. with the fire-door open. The speed was 40 miles per hour. While running there was no smoke, and none at the stations. The fire-box was examined at the end of the trip and very little clinker was found, and the smoke-box was free from cinders and dust—a proof that the fuel had stood the blast well; and it is the recorded opinion of the experimenters that the peat was in every respect well suited for locomotives.*

A trial on the Paris and Lyons (France) Railroad is thus reported by the engineer: We got up steam with peat in thirty minutes, coal requiring two hours. We ran 16 miles to a gravel pit, up a steep grade, and from there took a load of 136 tons 80 miles further, when the blaze escaped a considerable distance above the chimney which became red hot, and the boiler covering taking fire we had to stop and extinguish it. After repairs we returned to Paris at a speed of 38 miles per hour, the heat again increasing as we advanced. The fuel having no smoke and much gas keeps up a constant hot flame. The pressed peat gives far better results than that which is not pressed. In fact while using it the generation of steam was so rapid that I stood with my hand on the valve lever all the time fearing an explosion.†

A trial was made on the New York Central Railroad January 3, 1866, of which the following account is furnished us by the master machinist: Left Syracuse at 8 o'clock and [illegible] minutes (40 minutes behind time) with 25 empty 8-wheel box freight cars. Started with 120 lb. of steam. The engine worked well and took us along pretty sharp, as we made up the 40 minutes in going 25 miles and arrived at Port Byron on time. The steam did not run below 120 lb. any of the time and was often from 125 lb. to 130 lb. When the engine was working the strongest she would steam the best. We made time all the way very fast, although we had a strong head wind all the way, and snowing at times quite fast, and very cold. We took on a trifle over four tons of peat at Syracuse which was all we had . . . . Five tons of peat would have taken us to Rochester with the train we had although it was a very bad day. The same engine would have used about 3½ cords of wood in running to Palmyra, while we used not quite 4 tons of peat for the same distance. It gave as much steam as wood and burned a beautiful fire. Our trip was a perfect success, and I am sorry there were not not more present to witness it. We used a coal-burning grate.‡

Accounts of similar experiments on the Hartford and Springfield Railroad, the Hudson River Railroad and the Eastern and the Vermont Central Railroads are given in the same volume from which the foregoing extracts have been made, and in every case successful results are said to have been obtained.

GRAND TRUNK EXPERIMENTS.

In 1866 the authorities of the Grand Trunk Railway experimented pretty freely with peat, using the condensed article made by the Hodges process at Bulstrode, Que. The effect of the trials was apparently to show that peat could be used with advantage as a locomotive fuel. So satisfactory indeed did the company consider the result that a contract is stated to have been entered into extending over five years or seasons, during the first of which it was to take 100 tons per day, and during the four succeeding seasons 300 tons per day.§

Following are the particulars of some of these experiments: Well dried peat fuel was used with engine No. 158, 5-feet driving wheels, 16-inch cylinders, and 26-inch stroke, drawing twelve loaded cars.

Distance run per ton of 2,240 lb. of fuel	40.33 miles.
Fuel used per mile.	55.54 lb.
Greatest pressure of steam...	140 lb.
Least pressure of steam	100 lb.

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*Facts about Peat, by T. H. Leavitt (1867), pp. 201, 203, 204. †*Ibid*, p. 206. ‡*Ibid*, pp. 208-9. §*Ibid*, p. 98.

During the experiment fuel was put on in small quantities. No smoke issued from t stack, a steady, brilliant, white fire was kept up, and steam generated with great rapidit The damper was kept closed and air admitted through a slot in the furnace door. Not a atom of ash or cinder was left in the smoke-box, ash-pan, or upon the wire gauze of spar catcher. The grate inside was one of Lester's patent, having a well in centre with hor zontal openings to admit draft. The bottom of fire-box was scarcely ever entirely co ered with the fuel, the steam being generated too rapidly to allow of a large quantity fuel being put into the furnace.

Experiment with green peat fuel containing 25 per cent. of water, upon engine No. 6 6-feet driving wheels, 15-inch cylinders, 21-inch stroke, drawing an express train of 9 pa senger cars all heavily laden, from Montreal, going west, October 3, 1866:

Distance run	101 miles.
Fuel used	8,000 lb.
Fuel used per mile	79 lb.
Average speed, including stoppages, per hour	23 miles.
Greatest pressure of steam	123 lb.
Least pressure of steam	90 lb.

This experiment was one to show whether with an engine out of order and very muc overburdened, steam could be made with green peat in sufficient quantities to meet an u ceasing demand during the whole time of running. . . Abundance of steam was raise and for a distance of many miles the pressure of steam did not vary. On the return tr next day, with a similar weight of fuel and train of six passenger cars, like results we obtained, but the quantity of fuel used per mile was reduced to 71 lb.

Experiment with engine No. 65, in good working order, and with peat fuel containi about 20 per cent. of water (express train consisting of six passenger cars):

Total distance run	177 miles.
Total consumption of fuel	7,936 lb.
Consumption per mile	45 lb.
Maximum consumption between stations	60 lb.
Minimum consumption between stations	30 lb.
Average speed including stoppages	25½ miles.
Greatest pressure of steam	125 lb.
Least pressure of steam	86 lb.
Distance run per ton of fuel	50½ miles.
Cost of fuel for the trip at $3.50 per ton	$12.25
Cost per mile run for fuel	7 cents.

On the return trip the consumption of fuel was less, the train being lighter.

Another experiment was made on the same road with the view of determining wheth with a diminution of the blast the same quantity of steam could be generated as obtain on former occasions with the blast usually employed for wood. By this diminution of t blast additional power was gained and the consumption of fuel smaller than on any pr vious occasion.*

Notwithstanding the seemingly favorable results of these and other trials, peat h not been adopted by the Grand Trunk railway as a fuel for use in its locomotive perhaps some experiments made at a later date, and with compressed peat of differe manufacture may have led that company to the conclusion that as coal has answered i purpose in the past it may be trusted to do so in the future.

As it is not the purpose in this paper to overrate the qualities and advanta of peat, but to state as fairly as possible the conclusions which experience an careful experiment have reached, whether such conclusions be favorable or adverse, t following particulars are appended of comparative trials of peat, wood and coal, made b the Grand Trunk railway company in 1876, such particulars having been furnished t Bureau by Mr. E. Wragge, local manager Grand Trunk railway company, Toronto.

Experiments on the comparative values as fuel of coal, peat and wood in locomoti engine No. 303, built by the Rhode Island Locomotive Works, and running between Mon

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*Facts about Peat, p. 212 *et seq.*

and Richmond on Nos. 9 and 10 freight trains; cylinder 17 in. x 24 in., drivers 5½ feet diameter. James Millar, engineman; Wm. Walklate, inspector.

	Peat.	Wood.	Coal.
Date of experiment	Sept. 23.	Oct. 3.	Oct. 5.
Description of fuel	Compressed.	Hard maple.	Russell new black vein S. Wales.
Train miles	145	145	145
Car "	3,134	3,279	3524
Ton "	49,407	48,433	50,337
Average train tonnage	340	334	347
Average car "	15.76	14.77	14.29
Average cars per train	21.58	22.61	24.30
Fuel consumed, in lb	17,925	12,780	5,330
Fuel consumed, in lb, per train mile	123.62	88.13	36.75
" " " car mile	5.71	3.89	1.51
" " " ton mile	.362	.263	.105
Water evaporated in lb per lb of fuel	2.33	3.09	7.94
" " total lb	41,820	39,520	42,330
Time occupied in experiment, hours	13¼	14¼	15
Speed in miles per hour, deducting stops	17¼	16	14¼
Hours engine was under steam	17	17	17
No. of stoppages on trip	140	168	156
Average boiler pressure in lb per square inch	120	130	135
Weather	Fair & warm.	Fair & mild.	Rain & cool.
Wind	Slight.	Strong side.	Strong side.
Rails, condition of	Good.	Good.	Moderate.
Price of fuel	$2.53 per 2240 lb	$2.88 per 4031 lb	$4.77 per 2240 lb
Cost in cents of hauling 100 tons one mile	4.09	1.87	2.24

N.B. Peat delivered at St. Lambert's; wood sawn and delivered on G. T. R. track; coal in pile at Point St. Charles.

G. T. Ry. Mechanical Supt's Office,
October, 1876.

(Sgd) HERBT. WALLIS,
Mechanical Supt.

Similar experiments were also made under the direction of Mr. Wallis at the same time with the view of ascertaining the value of peat for use under stationary boilers, as compared with wood and coal, which, though more favorable in their results to peat than the experiments detailed above, nevertheless failed to show its superiority over its rival fuels.

Experiments on the comparative value of fuel of coal, peat and wood in No. 1 stationary engine:

Diameter of cylinder	22 inches.
Length of stroke	42 "
Engine	Horizontal class.
Outside lap	1 5/16 inches.
Inside lap	5/16 "
Lead, front	3/16 "
Lead, back	1/8 "
Heating surface of box	150.89 feet.
" " tubes	1,094 "
Boiler area of fire grate (locomotive class)	1,868 "

	Peat.	Wood.	Coal.
Date of experiment	Oct. 12-13	Oct. 17-18	Oct. 19-20
Description of fuel	Compressed.	Hard maple.	Russel new black vein, Wales.
Price	$2.53 per 2240 lb	$2.88 per 4031 lb	$4.77 per 2240 lb
Average temperature of atmosphere	48.83°	41.02°	48.19°
Fuel consumed, in lb	18,157	17,065	6,615
" per h.p. per hour	18.96	18.31	7.30
" per hour	955.63	898.15	348.15
Total ashes, lb	532	265	649
" per 100 lb. fuel	2.92	1.49	9.81
Average boiler steam pressure per square inch	81.54	80.88	76.07
" cylinder " " "	13.97	13.88	13.33
Greatest initial pressure in cylinder	39	35	35
Average indicated horse power	50.40	48.95	47.63
" number of revolutions per minute	44.76	43.76	44.33
" piston speed in feet per minute	313.32	306.72	310.31
Total hours under steam	19	19	19
Cost in cents per h.p. per hour	2.14	1.30	1.55

N.B. Peat is delivered on G.T.R. cars at St. Lambert's; wood on track and sawn at various parts of the line; coal in coal pile at Point St. Charles.

G. T. R. Mechanical Supt's Office,
Montreal, Oct. 31st, 1876.

(Sgd) HERBT. WALLIS,
Mechanical Supt.

Mr. Wallis, in his report to the Grand Trunk Company upon these experimen remarks that they show the peat to be better adapted for stationary boilers than for lo motives on account of the heavy work performed by the latter, but that it cannot co mence to compare economically with coal or wood in either stationary or locomot boilers. He enumerates the defects of the peat as a locomotive fuel thus:

> It loses materially in weight, it is very objectionable to fire on account of the pai inflicts upon the eyes, it is very liable to be set on fire, it requires a different kind of g to burn it, it is not impervious to the weather, and it causes very considerable delay u the road in wet weather.

It is evident from the results of these experiments that the peat which Mr. Wa had under trial was of inferior quality, and although it is stated to have been "c pressed," the fact that he objects to it on the score of its losing materially in wei shows that it cannot have been properly dried. No one could pit green or air-dried p against dry hard maple or Welsh coal with the expectation that it would comp favorably with either. The tests appear to have been fairly and carefully made, bu the peat was not a representative article in point of quality, as is probable was the c they ought not to be considered as conclusive evidence of its inferiority to the other f with which comparison was made.

The later trials made by Mr. Brown for the Canadian Pacific railway company, well as the previous tests on the Grand Trunk railway, afford sufficient ground for beli ing that, while not equal to coal, peat when properly prepared has some not inconsi able advantages in its favor, and can under certain circumstances be used as an effici substitute.

MODE OF BURNING PEAT.

With respect to the way in which peat may be burned, Prof. Johnson says:

> In the employment of peat fuel regard must be had to its shape and bulk. Flat bl are apt to lie closely together in the fire and obstruct the draft. A fireplace constru properly for burning them should be shallow, not admitting of more than two or t layers being superposed. According to the bulkiness of the peat, the fire-place shoul roomy as regards length and breadth. Fibrous and easily crumbling peat is usu burned upon a hearth, *i.e.*, without a grate, either in stoves or open fire-places. D peat burns best upon a grate, the bars of which should be thin and near together, so the air may have access to every part of the fuel. The denser and tougher the peat, the more its shape corresponds with that usual to coal, the better is it adapted for us our ordinary coal stoves and furnaces.*

PEAT CHARCOAL.

Peat can be reduced to charcoal in a manner very similar to that employed in case of wood, and the proportion of carbon contained by peat being greater than that wood, the percentage of charcoal yielded is correspondingly greater.

The average quantity of charcoal produced by the common stack or meiler pro from ordinary wood is about 22 per cent. When the distillation is carried on in c ovens this quantity is frequently increased to 27 per cent.; but as about five per cen required for heating the oven this method in reality affords results very little superio those obtained from the common charcoal-mound. Peat, on the other hand, yields f 23 to 35½ per cent. of its weight in charcoal on being charred in the ordinary way; product of carbonization in ovens is not greater than that obtained by the ordinary cess, yet the supply of air and the rapidity of charring being more easily regulated, operation is more cheaply executed when ovens are employed.

Lignite yields from 29 to 62 per cent. of charcoal or coke, while from the most s able sorts of bituminous coal as much as 90 per cent. of their weight is yielded in co ordinary yields are from 65 to 75 per cent.

The charcoal of peat is largely used on the continent of Europe for domestic purpo its price being about the same as that of wood charcoal, and nearly twice that of min coal.

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* Peat and its Uses, pp. 102-3.

It would seem that peat charcoal might be introduced as a fuel for household use here provided always it could be produced and sold at a price not greater than its equivalent in wood or coal. As to this it is stated that peat charcoal has been manufactured in Ireland at a cost of not more than 8*s.* 4*d.* ($2) per ton, but as applied to its cost here this is undoubtedly too low an estimate.

Mr. E. B. Borron gives it as his opinion that with the aid of recent discoveries peat charcoal may be manufactured in Ontario for $4 per ton on the spot where the peat mosses are situated.*

The selling price of this article in Paris, which appears to be not less than $25 per ton, would seem to preclude the possibility of producing it at so low a cost as that named by Mr. Borron, otherwise it might be expected that competition among manufacturers would have the effect of lowering its price. The high esteem in which it is held is shown by the fact that the people of Paris are willing to pay twice as much for peat charcoal as for an equal weight of coal, or even more, and thousands of tons are annually consumed in that city.

ITS VALUE FOR IRON FURNACES.

The principal purpose for which coke is used is the smelting and manufacture of iron, the large proportion of carbon which it contains rendering it capable of producing the high temperature requisite for the successful carrying on of the processes.

Peat and coal have been employed in their uncarbonized condition for the smelting of iron ore, peat generally in conjunction with coal, while the latter is sometimes employed alone. Better results are obtained when the fuel is used in the carbonized form, as coal usually contains a considerable percentage of sulphur which is very deleterious to the product of iron, and which is wholly or partially got rid of by carbonization, and the charcoal and coke yield a greater intensity of heat in combustion than the raw fuels. Sir Lowthian Bell, one of the greatest living authorities on the manufacture of iron, places a low estimate upon the value of peat as a fuel for the smelting of iron. He says:

> In 1876 a trial was made with compressed peat at one of the Vordenberg furnaces. Particulars of the experiment are given by Anton Einigl. When about 29 per cent. of the total weight of fuel was peat, the remainder being charcoal, the actual work done was such that one ton of the charcoal was worth nearly three tons of the peat. The low value of peat as a blast furnace fuel is due to the large quantity of water and volatile gases it contains. Of the really useful constituent, viz., fixed carbon, it gave only in this case 82 per cent. The statements just made in reference to lignite and peat may be accepted as an indication of the great inferiority of these varieties of fuel as compared with charcoal or ordinary coke, for the purpose of smelting iron.†

At Konigsbronn in Wurtemburg, at Ransko in Bohemia and elsewhere on the continent of Europe, on the other hand, satisfactory results are said to have been obtained in the smelting of iron by the use of air dried peat alone or mixed with a nearly equal weight of wood charcoal. Peat has even been used in Canada in the manufacture of iron, and to good effect, as will be seen by the following statements:

> Mr. McDougall, of the Caledonia Iron Works, Montreal, who supplies the Grand Trunk railway with car wheels, states that for giving toughness to the metal and uniformity of chill, qualities so essential to car wheels, peat fuel is unsurpassed. We have the following brief report of an experiment in smelting iron with peat at these works made in October last (1866). The cupola was charged with two layers of iron and anthracite coal. The third and topmost layer was iron and peat. The time was forty minutes less than with coals alone. The iron smelted by the peat was hotter when drawn off from the coals and was said to be more compact and more like wrought iron than the other. The test was a severe one, the proportion being twelve of iron to one of peat; the proportion for coals being seven to one.
>
> The Montreal Gazette of December 1, 1866, says: We were shown yesterday a small piece of bar iron from the puddling and rolling mills of Messrs. Morland, Watson & Co., from the first blooms ever made in this country with peat fuel alone, and we believe the first on this continent. The specimen shown to us was of the very highest quality and equal to the very best Swedish iron. It was bent when cold by a vice, and doubled close up at right angles with an edge, without a crack or flaw appearing, the outer edge remain-

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* Ontario Sessional Papers, 1881, No. 44, p. xix.

† Principles of the Manufacture of Iron and Steel by Sir I. Lowthian Bell, pp. 136-7.

ing smooth and sharp. A severer test of the tenacity of the iron could not have been applied. . . We may add that the time taken in the manufacture was not greate than that usually taken when coal is used. There was no special adaptation of appliances. The furnace was an ordinary coal one, and the men were accustomed to the use of coal.

Mr. Campbell, manager of the mills above referred to, states that the peat fuel wa tested in an ordinary puddling coal furnace, and no alteration or adaptation was made although this might have been done and a large saving of fuel effected. The pig-iron used was Dalmellington brand A, a strong iron, soft and very tough. The quantity of peat fue consumed was nearly double the weight of coal used on ordinary occasions. In my opinion, and with the present furnaces, by mixing peat with Pictou coal we could produc iron equal to the best charcoal iron, and at no more expense than the present cost of ou iron, the quality of which is equal to the best refined English iron.*

Peat charcoal, especially that made from compressed peat, appears to be much preferable to the uncarbonized article in the smelting or refining of iron. Charcoal prepared from common air-dried peat is subject to disadvantages which prevent its general application to ordinary metallurgical purposes. Being light and friable it soon falls to pieces, and is thereby rendered worthless as a fuel. In smelting furnaces where it has to sustain the weight of the charges above it, this charcoal is found to crumble and choke the blast, and it can therefore be employed only under steam boilers, in forge fires, or in reverberatory furnaces † By coking compressed peat however the resulting charcoal may attain a density of 1.040, which is far superior to that of wood charcoal and even equal to that of the best coke made from coal. In its calorific effects this charcoal is about the same as coal coke, and little inferior to wood charcoal.‡ One advantage over coke which peat charcoal possesses in common with wood charcoal is its freedom from sulphur,§ which is frequently present in the former in proportions as high as one or even two per cent., to the great detriment of the iron produced.** Tests made in England as well as elsewhere show that peat charcoal may be made to serve a very important use in the puddling and refining of iron, and in southeast Germany and Russia it is extensively used in metallurgical operations.

The charcoal made from peat at Horwich, England, is extremely dense and pure. Its heating and resisting powers have been amply and severely tested, and with the mos satisfactory results. At the Horwich works pig-iron has been readily melted in a cupola About 80 tons of superior iron have been made with it in a small blast furnace, measuring only six feet in the boshes, and about 26 feet high. The ore smelted was partly red hematite and partly Staffordshire; and the quantity of charcoal consumed was 1 ton 11 cwt. t the ton of iron made; but in a larger and better constructed furnace considerably les charcoal will be required. It has also been tried in puddling and air furnaces, with equally good results, considerably improving the quality of the iron melted. For thi purpose the fuel was only partially charred, in order not to deprive it of its flame, which is considerably longer than that from coal. Some of the pig-iron made at Horwich wa then converted into bars, which were afterwards bent completely double when cold, without exhibiting a single flaw. . . .

Mr. Fothergill, when reporting on experiments with peat-charcoal iron conducte under his supervision at Messrs. Platt's iron works at Oldham, says: "I have no hesitation in stating that the experiments were a great success. The directors can judge of th tenacity and quality of the iron from the severe character of the test to which it has bee submitted, namely, having been completely doubled over when cold without exhibiting single crack." . . .

Professor Emmons, geologist to the State of New York, concludes some remarks o the subject of peat as follows: "I shall state only one more application of this material viz., as a substitute for charcoal in the reduction of iron. The coal which is formed fro it is equal to any coal, hence it may become of great importance in those sections o country where fuel is scarce, or as it furnishes a resource in this important business whe the ordinary means are expended.††

Sterry Hunt, in the report of the Geological Survey of Canada, 1866, refers to th trials made a short time before with peat for puddling iron in Montreal, which he state gave satisfactory results, "as might have been expected from the success which ha so long attended its use for such purposes in Europe." Dr. Hunt further makes mentio of an ingenious application of peat to the smelting of iron by Mr. Hodges, whose method of preparing peat fuel has already been described. This application, as stated by Dr. Hunt, consists in moulding a mixture of magnetic iron-sand with pulped peat into bricks, which when dried and treated in a proper furnace, readily yield malleable iron by a single operation, the particles of ore being enveloped in a reducing matrix. This sand is found in considerable quantity on the shores of the lower St. Lawrence, and wherever it can be cheaply obtained may probably be wrought with advantage by this method.

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* Facts about Peat, pp 194-5.

† Elements of Metallurgy, p. 612.

‡ Ure's Dictionary of Arts, Manufactures and Mines, vol. III. p. 522.

§ Facts about Peat, p. 190, etc.

** Materials of Engineering, Part I. p. 180.

†† Facts about Peat, pp. 191-3.

Dr. Hunt goes on to say: "Mr. Hodges has further suggested the application of this process to the treatment of artificially pulverized magnetic and specular iron ores, which in the vicinity of the great beds of these ores, so abundant in this country, can probably be obtained at a much less cost than iron-sand, so that this process, if we may judge from the results of the first experiments, is destined to render our peat deposits very serviceable for the manufacture of iron."*

FUEL FOR REGENERATIVE GAS FURNACES.

The Siemens' regenerative gas furnace, the great invention of the brothers Siemens, which has been so extensively used in the manufacture of iron and steel, appears to have opened up a wide field for the employment of peat which it is somewhat surprising has not been more extensively availed of. The fuel employed for the production of gas for use in this furnace is usually bituminous coal, but coke, lignite, peat and even sawdust may be used for the same purpose, as whatever the fuel may be, it is not burned with the view of applying its heat directly to the contents of the furnace, but rather subjected to a process of distillation or imperfect combustion with the object of producing gases, mostly carbonic oxide (C O) and hydrogen (H). These gases are conducted to the regenerators where, streaming through a mass of loosely piled fire-bricks previously heated by the waste gases escaping from the furnace, they are raised to so high a temperature that on entering the furnace proper they immediately enter into combination with the atmospheric air which has passed through a similar regenerating chamber, and so produce an exceedingly intense heat with a great economy of fuel.

Dr. Reynolds, as the chairman of the committee of the Royal Dublin Society on the use of peat by Siemens' regenerative furnace reports very favorably of its use in manufactures requiring intense heats. Ordinary air-dried peat containing on an average 25 per cent. of water when used in this furnace compares more favorably with coal than in any other way. The general heating power of 2¼ tons of peat is equivalent in practice to that of 1 ton of average coal, but in the Siemens furnace its value appears equivalent to not less than 65 per cent. of that of Staffordshire coal.† When fuel containing water is used for the production of gas in this furnace, the resulting moisture must be got rid of, as its presence is very objectionable. To accomplish this the gas as it comes from the producers is passed through cooling tubes which condense all the moisture present. This provision enables fuels containing very large proportions of water to be utilized; indeed Dr. Hunt informs us that by the aid of the Lundin furnace, combined with the regenerators of Siemens, steel has been produced using only pine sawdust as fuel. He adds: "When such results can be obtained with sawdust or ordinary peat, the want of mineral coal need no longer be an obstacle to the development of the metallurgical industry of this country."‡

In the natural gas fields of the United States that fuel has proven itself exceedingly economical and valuable when applied to a great variety of industrial uses, such as the manufactures of steel, glass, etc., while for domestic purposes, both of heating and lighting, it is highly prized by the inhabitants of those districts.

The use of gaseous fuels presents many advantages, which are summarized by Thurston as follows: (1) Convenience of management of temperature, (2) freedom from liability to injure material with which the products of combustion may come in contact, and consequently also allowing the use of fuel of inferior quality as a source of the gas, (3) the facility with which thorough combustion may be secured, (4) the readiness with which the flame may be given either an oxidizing or a deoxidizing character, and (5) in many cases economy in expense of operation. The disadvantages are, (1) danger of explosions when carelessly or unskilfully handled, and (2) expense of plant.*

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* Geological Survey of Canada, 1866, p. 291.

† Ure's Dictionary of Arts, Manufactures and Mines, vol. III p 526.

‡ Geological Survey of Canada, 1868, p. 298.

The advantages of natural gas, which include all those given above, so far outweigh its disadvantages, as to cause those who have once used it to be very unwilling to give it up. This course however appears likely to be forced upon a great many consumers in the gas fields of the United States, where the flow of that useful mineral is steadily decreasing and threatens in time to cease entirely.

Under these circumstances it is probable that other sources of a gas which may take the place of the natural article will be sought for. As has been shown above, gas answering admirably for use in the Siemens' regenerative furnace can be obtained from peat, while it is also well known that gas of high illuminating power can be distilled from the same article in a well-dried state.

On Dartmoor, England, the peat is cut by convicts working in gangs, and being dried it is carefully stored away in one of the old prisons. From this peat by a most simple process gas is made with which the prisons at Princetown are lighted. The illuminating power of this gas is very high. The charcoal left after the separation of the gas is used in the same establishment for fuel and for sanitary purposes, and the ashes eventually go to improve the cultivated land in that bleak region.†

Professor Emmons in his report on the Geology of New York, says: Peat furnishes an abundance of carburetted hydrogen, and hence may be employed for producing gas-light. Dr. Lewis Feuchtwanger, of New York, has made known to the American public the experiments of Merle, a director of a gas-light company in France. The advantages of peat for the production of gas are as follows: (1) It is less expensive than gas from coal, oil or resin, (2) the product is nearly as much as from those substances, (3) the gas is quite harmless and inoffensive, and has in respect to healthfulness great advantages over some of the other kinds of gas. After it has been used for gas the coke may be employed as fuel, and is equal to any charcoal.

Other experimenters return its yield of gas as considerably in excess of that of bituminous coal, and equal to that of the best cannel coals. The chief impurity in peat gas is carbonic acid, which is present in considerable quantity, especially if the peat from which it is manufactured is insufficiently dried.

It is possible that the electric light will in time supersede gas altogether for lighting purposes, and so render the use of peat for the production of illuminating gas unnecessary, but should the threatened failure of natural gas in Ohio, Pennsylvania and elsewhere actually take place the users of that article for heating and industrial purposes may with advantage to themselves investigate the possibility of utilizing peat as the source of an efficient substitute.

A beginning has been made in the use of natural gas in our own province, and when we have consumed or wasted the store which provident nature has laid up for our benefit, or exported it to another country, we shall be in a position to benefit by the researches and experience of the people of the gas-producing states to the south of us.

OTHER USES OF PEAT.

There may be procured from the destructive distillation of peat a variety of chemical products, of greater or less value. These include sulphate of ammonia, acetate of lime, pyroxylic spirit (wood alcohol), naphtha, heavy and fixed oils, and paraffine. Various attempts, notably in Ireland and on Dartmoor, England, have been made to obtain these substances on a commercial scale, but such operations appear to have usually resulted in loss.

Peat charcoal is highly esteemed as a disinfectant and deodorizer, and it is also used as a filtering medium for foul water and sewage. The raw peat itself is applied to certain soils as a fertilizer with good effect, supplying a considerable proportion of nitrogen and vegetable humus. The ashes of peat and peat charcoal are also valuable manures.

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* The Materials of Engineering, Part I., p. 190.

† Ure's Dictionary of Arts, Manufactures and Mines, vol. III. p. 523.

The upper portions of peat bogs consisting of growing and undecayed mosses are utilized in Germany in the production of "moss litter," which is simply such mosses teased and opened out and freed from dust and other impurities It is baled like hay and shipped in quantities to London, England, and other large cities where it is used as bedding for horses. It has the property of absorbing as much as twenty-five times its own weight of moisture, and when it has fully served its purpose in the stable is in a condition to be used as a very valuable fertilizer.

GENERAL CONCLUSIONS.

The fuel question is one of such importance, and touches the general welfare so closely, that no apology will be required from the Bureau should it recur to the subject on a future occasion. It would be desirable to submit further information as to the extent to which the use of peat obtains in other countries at the present time, the forms in which and purposes for which it is employed, and the modes of its manufacture which have stood the test of time and experience. Here in Ontario the whole question is in its infancy ; peat fuel is as yet a thing practically unknown, and it is the part of wisdom to avail ourselves of the experience of other nations in order that we may be warned by their failures and may profit by their successes.

Meantime, the facts which have been presented in the foregoing pages may warrant the following conclusions :

1. The peat-bogs of older, and more especially of newer Ontario, are of great extent in the aggregate, and should an economical process be devised for the manufacture of a good fuel therefrom their future importance can hardly be over-estimated.

2. Air-dried peat, from its bulkiness and the considerable percentage of water it usually retains, is not likely to come into general use in Ontario so long as wood and coal do not rise materially above their present price.

3. The tendency of both wood and coal to rise in price will undoubtedly have the effect of turning attention to other kinds of fuel, of which peat is one of the most available.

4. A first-class article may be produced from the crude material by various methods of compression or condensation, particularly when coupled with the application of artificial heat, but it has hitherto been at too great a cost ; and as a source of gaseous fuel for use in manufacturing centres peat offers considerable advantages.

5. For domestic use, for generating steam under stationary boilers and for heating purposes generally, there is every reason for believing that a good peat fuel would answer admirably ; while for railway or steamboat use, or wherever space is a prime consideration, it would seem that peat must take second rank to coal.

6. It is an object of national importance to obtain, if possible, a home fuel which will render us independent of a foreign country for one of the necessaries of life ; and this aspect of the question becomes greatly intensified in view of the oppressive combination now formed in the United States to control the output and price of coal.

7. The progress which has been made, and is now being made, in the effort to manufacture a first-class fuel from peat which shall combine efficiency with economy affords good grounds for hoping that the day is not far distant when such a fuel will be presented to the people of Ontario. But the history of industrial development shows that the perfecting of processes is often slow and attended with many disappointments ; and before the problem of peat fuel has been satisfactorily solved many improvements in methods may yet be found necessary. T. W. G.

TECHNICAL INSTRUCTION.

The value of technical education in all departments of manufacturing or productive industry has long been recognized, and in the keen competition engendered by the conditions of modern life he who is best equipped with a knowledge of the principles and details of his business will, other things being equal, bear the palm.

It was once the prevailing idea that actual every-day work was the only kind of education worth anything in the way of imparting a genuine knowledge of any business. It is doubtless true that experience gained in this way is the best education, but there are many callings in which it is in the highest degree advantageous to the student to begin his career by laying down a foundation of technical instruction, leaving the practical work of his business to follow in its proper order.

Particularly is this the case with the man who intends to follow mining. In most countries where that industry has got beyond the experimental stage, the demand for skilled and educated labor to conduct and superintend the winning and refining of ores has led to the establishment of schools of one kind or other where instruction in the various branches of mining and metallurgy may be obtained.

MINING SCHOOLS IN FOREIGN COUNTRIES.

In Germany, France, England and the United States many institutions have been founded for the purpose of training miners and mining engineers, and of teaching the most approved and scientific methods of treating ores and minerals.

THE FREIBERG SCHOOL.

Perhaps the most famous school of mines in the world is the Bergakademie of Freiberg, Saxony, which celebrated its 125th anniversary last summer. It has the advantage of being situated in the heart of an important mining district where lead and silver ores are raised and treated in large quantities, and where the students are permitted to witness in the large smelting works adjoining the town the actual processes used in refining the ore. The staff consists of twelve professors with five assistant professors and docents, and instruction is given in mineralogy, geology, metallurgy, mining engineering, and the whole range of subjects bearing directly and indirectly upon mining. The laboratories are well equipped and the mineralogical collections complete. Liberal terms of admission are accorded to foreign students, and of an average attendance of 149 since 1878 there were 58 from foreign countries. A few of these were from Canada, and many from the United States, in which country a number of the most successful mining superintendents and engineers are graduates of the Freiberg school.

SCHOOLS IN THE UNITED STATES.

In the United States the Columbia School of Mines, the Massachusetts Institute of Technology, the Houghton School of Mines, together with the mining and metallurgical departments of a number of Universities and other institutions supply the demand existing there for skilled and educated labor.

The Columbia School of Mines is one of the best known institutions of its class in the United States, its main object being to train students to become professors in colleges as well as consulting, mining and civil engineers. A complete course extends over four years, and about 300 students attend annually.

The Michigan Mining School at Houghton, in the northern peninsula of Michigan, established in 1886, is modelled on a somewhat different type, the end at which its efforts are aimed being to turn out practical assayers, surveyors and draughtsmen, and to give instruction to the sons of miners and miners themselves which may fit them, with the experience gained in actual work, to take the position of mining superintendents. Being situated in a mining district every opportunity, as at Freiberg, is afforded the students to familiarise themselves with mining processes as actually carried on.

PRACTICAL METHODS IN NEW ZEALAND.

One of the most practical methods of education in connection with mining is that which has been adopted by the colony of New Zealand. Schools of mines are formed on the various gold and coal fields in which miners and others may receive instruction regarding the minerals in which they are interested. For the convenience of those engaged in carrying on their ordinary work during the day night classes are formed, and these constitute indeed an essential element in the scheme.

The course of study does not aim at being exhaustive, but rather at giving the miners an elementary but practical acquaintance with those branches of science most intimately related to minerals and mining matters, and at teaching them methods of determining minerals, how to ascertain the percentage of metals contained in ores, the best way of treating refractory ores, etc.

The system was begun in 1884, and in his report for the year 1891 the Minister of Mines thus speaks of the results obtained:

> Since the establishment of schools of mines throughout the colony the miners have far more knowledge about the mineral ores that are met with and the percentage of metals they contain. This will tend to cause mining to be conducted on a more intelligent basis, and cannot fail to produce a beneficial effect on the industry. The inauguration of this system of technical education is due to Professor Black, who by his energy and perseverance caused the miners in every district to take an interest in the subject, and by practical demonstration showed them that in order to follow their avocation with success it was necessary to be able to distinguish the mineral ores met with, and also their value. It must however be admitted that any system of peripatetic teaching can only have the effect of temporarily arresting the attention of those wishing to acquire knowledge on this subject, but it cannot be denied that it has a great impetus in inducing men to attend these schools for a considerable time in order to get a sound practical training. The greatest success attending this system of technical education has been at the Thames, where the teaching is carried on continuously by holding day classes for those who can attend, and night classes which the workmen from the mines and others avail themselves of. The result of teaching at this school last year has been very encouraging, the average attendance being forty-five regular students and fifty-one pupils from the public schools attending Saturday lectures. It is gratifying to find that many of the miners attending the night classes are taught drawing, mathematics, surveying, mining, geology, chemistry and assaying. The large attendance at this school and the great interest taken in the work may be partly attributed to the mines at the Thames being concentrated within a small radius, which admits of the workmen attending at night, and also to the large number of mineral lodes in this part of the colony containing complex and refractory ores requiring different methods of treatment from those formerly adopted to make them pay for working. . . . The expenditure on the schools last year amounted to £1,892, and the total expenditure since their inauguration six years ago has been £12,986, of which amount £3,000 was given towards the School of Mines in connection with the University of Otago.*

TECHNICAL SCHOOLS IN CANADA.

The comparatively backward state of the mining industry of Ontario must be attributed largely to other causes than the lack of skilled superintendence of mining operations, yet it is a fact that many ventures have come to failure through want of prudent and intelligent management. The geological formations of our province are so peculiar, and the modes in which minerals occur so different from those of other countries, that even experienced miners when first set down among our Huronian rocks find the knowledge gained in other lands of little avail and have often to confess themselves at a loss. And even when the search for ore in paying quantities has been rewarded with success, the refiner is sometimes confronted with pecularities in the nature of the ore which call for all available skill and intelligence. The sulphurous magnetic iron ore of some parts of eastern Ontario, the unique pyritous copper-nickel ores of the Sudbury region, the auriferous mispickel of the Marmora district and other ores present problems of treatment which may well engage the attention both of students and professors at any school of mines, and whose complete and economical solution would confer important benefits on the mining industries of Ontario.

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*Report of the Minister of Mines on the Mining Industry of New Zealand, 1891, pp. 13-14.

As yet technical instruction in mining and kindred subjects has not had much more than a beginning in Ontario. Most of the actual mining hitherto done in this province has been carried on under the direction of American or English superintendents, but it is gratifying to know that existing institutions of learning are recognising the importance of providing the youth of our province interested in mining with an opportunity of receiving such instruction as will fit them to take an intelligent part in the development of the mineral resources of their native province. The following information respecting the facilities afforded at the School of Practical Science, Toronto, Queen's University, Kingston, and McGill University, Montreal (which though in a sister province is conveniently situated for students from eastern Ontario) is furnished by the authorities of those institutions.

SCHOOL OF PRACTICAL SCIENCE, TORONTO.

The Mining Engineering department of the School of Practical Science has been included up to the present in the department of Civil Engineering, an option of suitable subjects being allowed in the third year.

This department is intended to afford the necessary preliminary preparation to students intending to become civil engineers (including under this term mining engineers).

Students who wish to devote themselves to the practice of mining engineering are allowed to take the work specially mentioned under this head in the third year, and to omit the work in experimental physics.

They are advised however to take, if possible, the regular course in civil engineering and the special work subsequently as special students.

The subjects for the first year are as follows: Mathematics, mechanics, drawing, surveying, chemistry; for the second year, mathematics, physics, experimental physics, drawing, engineering and surveying, chemistry, mineralogy and geology; and for the third year, experimental physics, drawing, engineering and surveying, applied chemistry, mineralogy and geology.

The appliances for the equipment of the department consist at present of (1) collections of minerals and models of crystals, of ores, of rocks, and of specimens to illustrate structural geology; (2) of blowpipe tables with the necessary tools; (3) of gas and charcoal furnaces, balances and other requirements for assaying. It is intended during the present year to add largely to the outfit above mentioned, and to provide collections, models and apparatus to illustrate the subjects of ore dressing and metallurgy.

The staff consists of a professor of Metallurgy and Assaying in addition to the Civil Engineering staff. There are now 67 graduates and 74 students in the combined departments of civil and mining engineering, the statistics of the two not having been kept separate.

Diplomas are given on completion of the three years' course, and provision is made for a fourth year's post graduate work.

Students of the Mining department of the School of Practical Science have access to all the courses of lectures and laboratory work in the University of Toronto in addition to the work of the school itself.

The fees for instruction in any of the departments are for the first year, $34; the second year, $44, and the third year, $54.

Diplomas are granted in civil engineering (including mining engineering), and the degree of Civil Engineer of the University of Toronto is open to candidates holding the diploma in civil engineering of the School of Practical Science who have spent three years in the actual practice of the profession of civil engineer. Candidates for this degree are required to prepare for the approval of the senate of the University an original essay on some engineering subject, accompanied with detailed explanations, drawings, specifications and estimates, and may also be examined on the subject of the essay as well as on the work or works on which they have been engaged.

The staff of the school is as follows :

J. Galbraith, M.A., M. Inst. C. E., Principal and Professor of Engineering.
A. P. Coleman, M.A., Ph.D., Professor of Metallurgy and Assaying.
W. H. Ellis, M.A., M.B., Professor of Applied Chemistry.
L. B. Stewart, P.L.S., D.T.S., Lecturer in Surveying (Secretary).
C. H. C. Wright, Grad. S.P.S., Lecturer in Architecture.
T. R. Rosebrugh, B.A., Grad. S.P.S., Lecturer in Sanitary Engineering.

QUEEN'S UNIVERSITY, KINGSTON.

Mineralogy, geology and chemistry, the subjects most nearly related to mining and metallurgy, have for many years received a good deal of attention at Queen's University.

When the present University building was erected in 1877-78 good laboratory, museum and lecture room accommodations were provided for these subjects. Since 1883 the development in the direction of sound practical work in chemistry, mineralogy and geology has been steady. Special attention has been given to assaying methods, to identification of minerals at sight and by simple tests, and to the study of mineral deposits in relation to geological formations.

The geology and mineralogy of Ontario have occupied a prominent place in the curriculum. The excellence of the work done in these directions is attested by the success of the science masters who have taken these courses at Queen's University, and by the fact that several of the graduates in chemistry, mineralogy and geology have, without any further special training been appointed to responsible positions as assayers and analysts. In estimating this fact it is to be remembered that the scientific work was done as part of a broad honor course in arts.

So far no special course has been marked out for those wishing to pursue merely technical studies.

This year (1891) the advance in the direction of mining and metallurgy has been rapid. The John Carruthers science hall has been completed and furnished, and now affords facilities rarely found even in more pretentious Universities than Queen's. There has been added to the staff, in the person of Mr. William Nicol, M.A., a man trained at Freiberg Academy, the best school of mines in the world; and the imperative demand for special courses for prospectors and others can now be more easily met.

The course of study comprises Latin, Moderns (or Greek), English, philosophy, mathematics, physics, chemistry, mineralogy, botany, zoology and geology. These are the subjects of course 12 for the degree of Master of Arts. Chemistry, mineralogy and geology are carried through the four (or five) years necessary to complete this course.

Chemistry of the first year embraces elementary chemistry and laboratory practice; for the second year advanced chemistry, simple qualitative analysis, blowpiping and organic chemistry; for the third year general chemistry, history of chemistry, organic chemistry, metallurgy, complex qualitative analysis, quantitative analysis and metallurgy; and for the fourth year general chemistry, history of chemistry, chemical technology, quantitative analysis, furnace and blowpipe assaying and metallurgy. Graduates frequently spend a fifth year in special work.

Mineralogy in the second year takes in elements of mineralogy, including general study of the properties of minerals, and the elements of crystallography; third year, systematic mineralogy, including crystallography, the classification of minerals, and the use of the blowpipe and other means of identifying minerals; fourth year, descriptive and and determinative mineralogy, including detailed study of the principal mineral species, and systematic testing to determine species, analysis of minerals and economic minerals of Ontario.

Geology covers in the second year lithological and dynamical geology, geological history of the globe, with special reference to the formations found in Canada; third year, physical geography, geology and palæontology, and examination and determination of minerals, rocks and fossils; fourth year, a special study of Canadian geology, examination of rocks, fossils, etc.

The building devoted to chemistry and mineralogy has a large lecture room, three class rooms, four laboratories, two balance rooms, a furnace assay room, a blowpiping room, a machinery room, and store rooms for the lecture room and for each of the laboratories. There are also the usual rooms for the professors, and a comfortable library and reading room.

The lecture room and laboratories are particularly well suited for their purposes. The building is not yet completely furnished, but the lecture room and two of the laboratories offer every facility for good work. The apparatus for lecture, class and laboratory work has been carefully selected, with a view to its being immediately useful. A large quantity of good material was brought from Freiberg by Mr. Nicol. This has been added to by subsequent orders. The collection of minerals is good, and is being constantly added to by graduates and other friends. Prospectors are availing themselves of the facilities here afforded, and are adding to the mineral collection.

Geology is taught in the main University building, where there is a lecture room and an excellent working museum for that purpose.

The staff for physics, chemistry, mineralogy, geology and mathematics consists of four professors, one lecturer, one assistant, and a lecture and laboratory assistant.

About twenty students annually complete the first two years. Of these about five finish the course.

The complete course in chemistry and mineralogy costs $24 for class fees and $40 for laboratory fees. Each year a deposit of $5 is made by each student at the beginning of the session. After breakages and fines are deducted, the balance of this is returned at the close of the session. The course in geology costs $12 for class fees.

At the close of the session in April, practical examinations are held in each subject.

The course outlined is for the degree of Master of Arts. For the Bachelor of Arts the subjects are not usually carried farther than the second year. No special degree in science has so far been instituted, but the necessity for special courses and degrees has become so pressing that steps are being taken towards establishing them.

The wants of prospectors are being met in a way which is so far satisfactory. Free access is given to the standard specimens of minerals for purposes of comparison, etc. The members of the staff always spare enough of their well occupied time to examine specimens, and to give information and direction. They also, so far as occasion permits, show simple ways of identifying minerals. Hardly a day passes but advantage is taken of these opportunities. In this part of Canada the interest in mines and minerals is becoming very lively.

The following gentlemen compose the staff referred to in the above memorandum:

Nathan F. Dupuis, M.A., F.R.S., Edin., Professor of Mathematics; N. R. Carmichael, M.A., Assistant.
D. H. Marshall, M.A., F.R.S.E., Professor of Physics.
James Fowler, M.A., Professor of Geology.
W. L. Goodwin, D.Sc., Professor of Chemistry.
William Nicol, M.A., Lecturer in Mineralogy and Metallurgy.
Alfred Deane, Laboratory Assistant.

McGill University, Montreal.

The instruction in the faculty of applied science in McGill University is designed to afford a complete preliminary training of a practical as well as theoretical nature to such students as are preparing to enter any of the various branches of the professions of engineering and surveying, or are destined to be engaged in assaying, practical chemistry, and the higher forms of manufacturing art. Five distinct departments of study are established, viz.: (1) Civil engineering and surveying; (2) Electrical engineering; (3) Mechanical engineering; (4) Mining engineering; and (5) Practical chemistry. The course in each of these extends over four years, and is specially adapted to the prospective pursuits of the student.

In the department of mining engineering the work includes such portions of the civil and mechanical engineering course as are essential to the education of a mining engineer. A thorough training is provided for in geology and mineralogy, and in order to give a practical character to the work frequent geological excursions are made and numerous minerals and rocks are determined and analyzed in the laboratory. In the lectures special attention is devoted to the economic aspects of geology.

Work in the chemical laboratory is begun in the first year and continued throughout the course, mainly consisting in the fourth year of assaying by the dry, wet and electrolytic methods.

In the third year a special course of lectures on mining is given. It is illustrated by diagrams and models, and includes the discussion of blasting, quarrying, hydraulic mining, boring; special methods of exploitation employed in the working of metalliferous deposits and coal seams; ventilation of mines, pumping, etc.

In the fourth year the lectures on metallurgy are illustrated by diagrams, models and collections of ores and metallurgical products.

The subjects of instruction in the mining engineering course are as follows:

In the first year, chemistry, English, French or German, mathematics, freehand drawing, geometrical drawing, shopwork.

In the second year, chemistry, English, French or German, mathematics, physics, surveying, zoology, drawing, physical laboratory and shopwork.

In the third year, chemistry, determinative mineralogy, geology and mineralogy, mathematics, mechanism, mining, physics, theory of structures, drawing, physical laboratory.

In the fourth year, assaying, geology and mineralogy, hydraulics, mathematics, metallurgy, applied mechanics, laboratory and museum work.

As yet there is no special mining laboratory in which practical operations in ore-dressing, etc., can be carried on, but it is hoped that this deficiency will be supplied in the near future.

The chemical laboratories are three in number, one for students of the first, one for the second and third years, in which it has been found necessary to carry on both qualitative and quantitative work, and one which is reserved for students of the fourth year and for special students who may wish to carry on original investigations. There is besides a special room in the basement which is fitted up for fire assaying.

An examination for the degree of Bachelor of Applied Science is held at the end of the fourth year, in all the subjects of that year.

The degree of Master of Engineering is conferred upon candidates who pass the required examinations. They must be Bachelors of Applied Science of at least three years' standing, and must produce satisfactory certificates of having been engaged during that time upon *bona fide* work in either the civil, electrical, mechanical or mining branch of engineering. They must pass with credit an examination extending over the general theory and practice of engineering, in which papers will be set having special reference to that particular branch upon which they have been engaged during the three preceding years.

The fees for all students, excepting such as entered previous to September, 1890, are $100 per annum, this amount including matriculation, tuition, gymnasium, library and graduation fees, and also the use of the machinery and other apparatus, as well as the cost of material in the workshops and engineering laboratories.

Of 126 students at present in the Faculty of Applied Science about 20 are taking the mining course or preparing for it.

The following gentlemen compose the staff of the School of Applied Science:

Sir William Dawson, C.M.G,, LL.D., F.R.S., Principal.

Henry T. Bovoy, M.A., M. Inst. C.E., F.R.S.C., Dean of the Faculty. and Professor of Civil Engineering and Applied Mechanics.

B. J. Harrington. B.A. Ph.D., F.R.S.C., Greenshields-Professor of Chemistry and Mineralogy.

C. H. McLeod, Ma.E. Professor of Surveying and Geodesy, and Superintendent of the Observatory.

G. H. Chandler, M.A., Professor of Practical Mathematics.

Charles A. Carus-Wilson, M.A., A.M. Inst. C.E., A. Inst. E.E., W. C. McDonald-Professor of Electrical Engineering..

John T. Nicholson, B. Sc., Thomas Workman-Professor of Mechanical Engineering.

W. A Carlyle, B.A.Sc., Lecturer in Mining and Metallurgy.

There are besides five Associate Professors and six Associate Lecturers.

T.W.G.

ALEXANDER MURRAY, F.G.S., F.R.S.C., C.M.G.

By Robert Bell, B.A.Sc., M.D., LL.D.

The subject of this biographical sketch was assistant provincial geologist of Canada (as it was before Confederation) from the commencement of the Geological Survey of the united provinces in 1843 till 1864, and afterwards director of the corresponding Survey of the island of Newfoundland from 1864 to 1883.

It was my good fortune to be tolerably well acquainted with Mr. Murray's history both in Canada and Newfoundland—otherwise I would not have attempted the present task. Not only was I associated with him for seven years at the headquarters of the Geological Survey in Montreal, but I accompanied him one year, as assistant, to his favorite haunts among the Huronian rocks of lake Superior and Huron, which, it is well known, he was the first to investigate; and, as regards Newfoundland, I have had opportunities of going over his work in different parts of the island and afterwards of discussing its geology with him during several weeks' residence at St. John's in the winter of 1868-69.

Mr. Murray was a friend of my late father, the Rev. Andrew Bell, who had given much attention to the geology of Upper Canada and had mapped the distribution of the rocks in the lake peninsula, according to the divisions which had been made by the geologists of the state of New York, before the commencement of the government Geological Survey of Canada. It was when on a visit to my father, in 1850, who was then living in Dundas, that I first saw Mr. Murray. Although only a boy at that time, I have a distinct recollection of him as a bright, genial and pleasant looking man. On this occasion my older brothers assisted him to measure the strata in the cliffs around the head of lake Ontario, among which was the "Sydenham Road Section," published in his report for that year, and which has been so often used for reference in regard to the rocks of the surrounding country. During this visit my father, who was familar with the country northward to Georgian bay, furnished Mr. Murray with information which enabled him to lay out his time in examining it to the best advantage—all of which he acknowledged in his report to the government. I renewed Mr. Murray's acquaintance in 1857, when I joined the staff of the Geological Survey, and have followed his labors to the close of his life.

Murray was born at Dollerie House, Crieff, in Perthshire, Scotland, on the 2nd of June, 1810, and died in the same town on the 16th of December, 1884, in his 75th year. He was the second son of Anthony Murray, Esq., of Dollerie House, Anthony being the eldest, and William, who was killed in the Indian mutiny in 1857, being the third son. They belonged to the family of the Murrays of Ochtertyre, referred to by the poet Burns in his song "Blithe was She," and were cousins of Sir Patrick Murray, the present proprietor of the estate of his forefathers.

Murray was educated at the Royal Naval College, Portsmouth, entered the navy in 1824 as midshipman, passed for lieutenant in 1833, and retired in 1834. Although he did not remain long in the service, the atmosphere of a man-of-war of those days clung to him throughout life. He was fond of nautical terms and illustrations and the strong language of naval officers of the olden time. On account of these peculiarities, when he removed to the seafaring colony of Newfoundland he was christened Captain Murray by the people, and among them was always known by this honorary title.

During his career as a naval officer he had an opportunity of seeing some active service, and was present in the "Philomel" at Navarino on the 20th of October, 1827, where he was wounded, and received a medal for the part he took in that engagement. At the time of the rebellion of 1837-38 in Upper Canada he volunteered his services to the government and was on duty for a short period.

The salary attached to the position of assistant provincial geologist does not appear to have been sufficient to secure his services for the entire year, and Murray was allowed to devote part of his time to agriculture. He purchased land in the township of Blandford, not far from Woodstock, one of the best districts in the upper province, and continued to hold his farm all the time he was connected with the Geological Survey of Canada. For the first few years he kept the management of it in his own hands, his wife looking after matters while he was absent on geological field work a part of each summer, or at the office of the Survey in Montreal a portion of each winter. He found however that in his case "gentleman farming" would not pay, and so he rented this property and took a house in Woodstock. Here his wife died in the winter of 1862-3 while her husband was temporarily residing at the headquarters of the Survey in Montreal.

Murray was a man of medium height, rather fair complexioned, with blue eyes and flaxen beard. He was well built and had powerful muscles until he was overtaken by a paralytic stroke previous to 1856, after which he refrained from performing the feats of strength in which he had formerly delighted.

He was noted as an ardent sportsman and lover of dogs, guns and fishing rods. But he confined himself to the lines he could follow in a wild country, and neglected most of the sports of civilized regions, such as horseracing, cricket, etc. But when Murray was a young man, before public sentiment became so refined as it is at the present day, he did not deny having a weakness for the "manly art" and some other sports which are now tabooed in "society."

The animals he killed during his surveys and explorations in the backwoods always formed a welcome addition to the diet of salt pork, and often it constituted the only food in camp. He was an excellent shot with both rifle and gun, and many a bear and deer fell under his aim, to say nothing of the multitudes of ducks, grouse, snipe, woodcock and other wild fowl. He had a great fondness for fly fishing, which he considered "the grandest sport in the world," and he would go into raptures over the capture of an extra big trout.

A cold bath every morning was regarded by Murray as more essential than his prayers, and no matter how inclement the weather might be, or how inconveniently his tent might happen to be pitched for getting at the water, he would never allow the cold, rain or wind, or such obstacles as a marsh, a jam of driftwood or the tangled brush, to prevent him reaching deep water and enjoying his "dip." Late in the autumn, after the snow had whitened the ground and the ice was forming around the shores, he still continued the practice with unabated rigor. Cleanliness was a sort of hobby with him, and he had a very poor opinion of anyone who did not "tub" with reasonable regularity. When on an exploratory "traverse" in the woods, if a river or a narrow lake lay across his course, he would not hesitate to plunge in and swim to the other side rather than lose time in making a raft, as most explorers do under such circumstances.

Socially, Mr. Murray was always in great demand during his sojourn both in Canada and Newfoundland, although he was not very fond of "going out" in society. When he and Sir William Logan were present in any social assembly they always formed the centre of attraction and charmed the company with their entertaining stories, jokes, or general conversation, and occasionally by a song. These were cheerful days in the Survey offices in Montreal. Every now and then the pleasant voice of Logan or Murray might be heard echoing through the rooms, and the dull quiet work over maps, rocks and fossils, was relieved by many a hearty laugh. A visit to the museum was a treat to strangers if they should be fortunate enough to be escorted through it by either of these men.

Murray's voice was seldom heard in public, yet he was a good speaker when occasion required. His speech at the Toronto banquet to Logan after his return, newly knighted, from the Paris Exhibition of 1855, was the best of the evening, and was regarded as a very fine effort. On 15th February, 1869, I had the pleasure of listening to his popular lecture on "The Economic Value of a Geological Survey," delivered in the Athenæum Hall in St. John's before a large and intelligent audience, which included the governor of the colony and most of the members of both branches of the legislature. The subject matter of itself, his method of treating it and the delivery, were all excellent and called forth a very hearty vote of thanks.

Mr. Murray having been the first to survey and map the river now known as the Petewawé, gave it this name after an old Indian friend of his whose principal camping place was at the mouth of the river, and who was well known to all frequenters of old Fort William, which stood on the opposite side of the Ottawa.

Mount Logan, in the Shick Shock range in Gaspé, was so called at the suggestion of Mr. Murray, and he also gave the names they now bear to many of the geographical features in the country north of lake Huron, which he was the first to lay down correctly on the map He was an excellent surveyor and astronomical observer, as well as a neat and skilful draughtsman, as witnessed by the numerous large and well executed maps of his in the office of the Survey. Most of his surveys were plotted with his own hands, in the field. The numerous latitudes which he took have been found of great service in fixing positions in many parts of old Canada and Newfoundland. His surveys of lake Nipissing and the various channels of French river, made in several different years, were found sufficiently accurate for the purposes of the Ottawa Ship Canal survey, and were adopted by the engineers of that project—Shanly, Clark, Perry, Norman and Galway—who gave him credit for the use they had made of them.

In 1842 the Geological Survey of Canada was instituted by the government, on a petition of the Natural History Society of Montreal, made at the suggestion of the late Rev. Dr. Mathieson. Mr. (afterwards) Sir W. E. Logan was apppointed provincial geologist, but owing to unfulfilled business engagements in England he asked for leave of absence and spent the winter of 1842-43 in the old country. Here he appears to have first met with the subject of our sketch in the beginning of 1843, and to have engaged him as his assistant. Little is known of Murray's early studies as a geologist, but even when a midshipman he appears to have had a taste for the science, and had some practical training under Sir Henry T. De la Beche, with whom he served on the Geological Survey of Great Britain during 1841; while his nautical education had already fitted him to undertake topographical surveying. He arrived in Canada in May, 1843, and immediately commenced operations in the western province, while Logan returned from England by Halifax the same spring. On his arrival the latter proceeded to the northwestern part of Nova Scotia and measured the celebrated section of the Carboniferous rocks at the Joggins, near the head of the Bay of Fundy, which is published in detail in the Report of Progress for 1843. He then went to the eastern part of Gaspé and examined the coast in detail from Cape Rosier to Paspebiac. This was the commencement of the Geological Survey, which has since been extended to nearly all parts of the northern half of the continent.

Murray wrote little for publication besides his official reports to the governments of Canada and Newfoundland. When the Royal Society of Canada was founded by the Marquis of Lorne it was made to include Newfoundland, and Murray was appointed one of the original Fellows. In 1882 he contributed to its Transactions an interesting paper on "The Glaciation of Newfoundland." He was elected a Fellow of the Geological Society of London in 1870, and in 1878 was created a C.M.G. through the recommendation of Sir John Glover, then Governor of Newfoundland.

When Logan and Murray commenced the Geological Survey of old Canada the greater part of the areas of both provinces were uninhabited, unsurveyed and unknown. The problem before them was to ascertain the general geological structure and the geographical distribution of the rock formations, in spite of these difficulties. The region was so vast that it required some courage for two men to undertake this task. It was impossible for them to map out the rocks without making their own topographical surveys simultaneously with the geological ones. They could only do this by following the rivers and lakes through the forests and mapping them out as they went along. These surveys have subsequently proved to be wonderfully accurate, considering the difficulties under which our pioneers had to labor, and ever since they were made they have been found to be of the greatest service, even up to the present time; and, as topographical surveys alone, they have repaid many times over their small original cost.

But in addition to much of this kind of work Murray made regional geological surveys of a considerable area on the north side of the north channel of lake Huron, of the area south and west of a line from Kingston to Penetanguishene, including the lake peninsula of Upper Canada, and of the country between the St. Lawrence and Ottawa rivers as far west as a line from Kingston to Bytown. Besides assisting Logan in exploring parts of the north shore of lake Superior, Murray's own work on that lake consisted of surveys of the Kaministiquia river, Dog lake and river, Michipicoten river and Batchawana bay, and also an examination of the south shore as far west as L'Anse and Limestone mountain, with a view to correlate the rocks of the two sides.

His topographical and geological surveys in the country directly north of lake Huron embraced a greater or less portion of the course of each of the following rivers: Echo, Garden, Thessalon, Mississaga, Serpent, Blind, Spanish, Whitefish, Wahnapitae, Sturgeon and Maskinongé; also lake Wahnapitae and numerous lakes connected with the Thessalon, Mississaga, Blind and Maskinongé rivers. Between Georgian bay and the Ottawa he surveyed most of the numerous channels of the French river, the Sturgeon, Maganetawan, Muskoka, Petewawé, Bonnechere, southwest branch of the Madawaska, and the head waters of the Otonabee river and many lakes connected with them, including lake Nipissing and Muskoka lake. In Lower Canada he surveyed the Bonaventure, St. John or Douglas-town, Matane and Ste. Anne des Monts, and assisted Logan (in 1844) to measure a traverse from the St. Lawrence to Baie de Chaleur by way of the Chatte and Cascapedia rivers. During the season of 1849 he was again with Logan in making a geological survey of the region between the Chaudière river and the Temiscouta road.

The early finding of nickel ore on the north shore of lake Huron is worth referring to in connection with Mr. Murray's work and the subsequent discoveries of this metal in such abundance in the Sudbury district. In 1848 Murray examined the Wallace mine, near the mouth of Whitefish river, where the initial discovery was made and which had been opened the previous year. The ore which he brought to the laboratory of the Survey at that time was found to contain 8.26 per cent. of nickel, "but as two-fifths of the specimen consisted of earthy materials which might readily be separated by dressing, the quantity of nickel in the pure ore which this would represent would equal nearly 14 per cent." The country rocks of the Wallace mine belong to the same part of the Huronian system as those in the vicinity of Sudbury Junction, which lies on their general strike to the northeastward.

The original work that Mr. Murray performed in Newfoundland during the twenty years which he devoted to it were of more service in making the island favorably known to the outside world than anything which had previously occurred. The economic results of the Geological Survey have been very important. Before it was commenced the interior of the island was unknown, even geographically, and the great value of its mineral, timber and agricultural resources was unsuspected. The fisheries were supposed to be the only source of wealth and the interests of the mercantile class were opposed to the development of any others. At first Mr. Murray's reports, pointing out the other riches of the island, were received with incredulity, but after a time there was a reaction in the opposite direction and a mania for mining and prospecting set in. Copper was successfully mined in large quantities in several places, but many speculative enterprises failed, and blame was unreasonably cast upon the Survey. The information contained in Mr. Murray's reports in regard to the timber led to the carrying on of lumbering operations in several quarters. These reports also showed the existence of considerable areas of cultivable land around bay St. George, and in the valleys of the Humber, Exploits and Gander rivers, and more serious atttention has since been paid to the agricultural capabilities of the colony. All this has given the people new ideas and has led to great changes in the positions of classes. The affairs of the colony are no longer controlled entirely by the merchants, nor do the working men depend so exclusively as formerly upon the fisheries. Other industries are springing up and a railway is being built across the island.

As before remarked, he was created a C.M.G. in 1878. He acted as aide-de-camp to Sir John Glover, Sir Henry Maxse and Sir Frederick Carter, respectively, while these gentlemen were Governors of Newfoundland. He was highly respected by all members of the different governments under which he served, and was most kindly supported by his brother officials who reciprocated his obliging disposition and good-will.

Having while in Canada been thrown so much into contact with the aborigines, and knowing their character, he became the great friend of the Indians of Newfoundland, some of whom served him for as long as fourteen years. They are said to speak of him yet as the best hearted man that ever lived. His house was their home in St. John's, and the photographs of Murray and his family are to be seen in all their wigwams, where they are highly prized.

While living in St. John's his manner was very unobtrusive and he appeared to care little for any society but that of his wife and family. Latterly he became a member of the Church of England and appears to have manifested a simple Christain piety. He enjoyed his full pay from the Newfoundland government to the close of his life, but no pension was granted to his family, who were left ill-provided for, and would have fared badly but for the great and continued generosity of Sir Patrick Keith Murray and the present laird of Dollerie, Mr. Anthony Murray, mentioned in a previous part of this article.

REPORT OF THE INSPECTOR OF MINES.

I have the honor to submit herewith my Report on the Inspection of Mines for the year 1891.

The mining industry for the year has not made as rapid progress as may have been anticipated by many. A limited population, with a limited capital, want of enlarged experience in mining, and in some instances want of training in management of work, as well as the serious difficulty of obtaining at reasonable cost suitable and necessary appliances for carrying on the work successfully, are among the causes which have retarded its development. But the chief obstacle which the operator has met is the high tariff wall reared at our boundary line, barring him from free access to the large market which otherwise would be open for the products of the mine.

As to many of the properties and mines referred to herein, full descriptions have already been given and will be found in my Report for 1890, and in the Report of the Royal Commission on the Mineral Resources of Ontario, to which reference may be made.

GOLD.

The gold locations in the vicinity of Rat Portage have been worked to a limited extent only during the year; most of them are lying idle. But the completion of the reduction works is likely to give a new impetus to operations, and considerable quantities of ore have been taken out on two or three properties since the works were started.

THE SULTANA MINE.

During the latter part of the season work was actively carried on at the Sultana mine and suitable machinery introduced, the use of which has greatly aided in the rapid development of the property. A considerable quantity of free milling ore has been taken to the reduction works at Rat Portage, and so the outlook at present is encouraging.

THE CRESCENT MINE.

The Crescent property is situated on lots 16 and 17 in the eleventh concession of Marmora. It was purchased by the Crescent Gold Mining Co. in July, 1890. The capital stock is $100,000, and the offices of the company are located at the mine and in Montreal. This mine had been extensively worked by the former owners, and from their 10-stamp mill several valuable shipments of concentrates were made. Work has been actively carried on by the present owners since November, 1890, and a considerable staff of laborers employed both in the mine and mill. Twenty-one men were at work late in December under the control of Captain John McFee of Belleville, who had charge of the work for the former owners. An incline shaft following vein matter from the surface has been sunk to the depth of 70 feet. The hanging wall is diorite and the foot wall is still covered with mineral, the vein being 50 to 60 feet in width. Several other openings have been made by drifts and stopings. The daily output is about 16 tons of ore, which is raised with a steam winch, dumped into a car and carried over the tramway a distance of 500 feet to the mill.

Three other separate veins of ore have been opened on this property on which considerable surface work has been done, and on one a shaft has been sunk to a depth of 60 feet, following the mineral nearly the entire depth.

A new mill has been built and operated since the 1st of August last, capable of treating 14 tons of ore per day of 24 hours, requiring five men to work it, three on the day and two on the night shift. Four cords of wood are consumed daily. The ore from the Blake crusher passes into self-feeding hoppers which supply the 10 stamps of Fraser and Chalmers make. The first amalgamation takes place in the battery boxes, passing through a 40-mesh screen; it then passes over two electroplated copper plates, 4 by 8 feet, and from them to the improved Frue vanners which separate most of the gangue matter from the mineral. The concentrates give an average of 80 per cent. The mill is three-quarters of a mile from Malone station on the Central Ontario Railway, and on the banks of the Moira river.

I had occasion to call the attention of the manager to an exposed abandoned pit and also to some parts of the machinery, which required fencing. The main works of the mine were in a satisfactory condition.

THE BELMONT MINE.

This new mine was visited in December. It is situated on lot 20 in the first concession of Belmont. It was purchased recently on option by the South African General Exploring and Mining Co. of London, England. Mr. F. R. Lingham of Belleville is the Canadian agent of the company.

The work was begun on this property by the present owners in September last with a force of 25 men, under the directions of Captain John O'Neal, who remained in charge until November. Since November Captain George Davidson has had charge of the mine. A. W. Carscallen of Marmora has the general management.

The Carscallen shaft, which is nearly vertical, has been sunk to the depth of 75 feet, following the ore from the surface to the bottom. This shaft is 10 by 10 feet, and follows a well-defined hanging wall of talcose slate, and is cribbed from the surface to the solid formation.

A second shaft, distant 600 feet from the former, known as the O'Neal, has been sunk to the depth of 24 feet through a similar class of rock and ore. The vein matter at the surface of this opening measures 52 feet in width. A third shaft, distant 500 feet east from the Carscallen, and called the Strickland, has been sunk to a depth of 32 feet.

In these shafts the vein matter contains a small percentage of sulphurets of iron and carries gold varying from $6 to $600 per ton as shown by numerous assays. The mill tests of the surface ore have determined its value to be $12 per ton. About 1,000 tons of ore have been taken out, and two car loads of the ore have been shipped to London, England, for treatment as a test. A gin is used for hoisting ore and the water which accumulates in the sump, but it is to be displaced by a steam hoist and pump for that purpose at the beginning of the new year.

This mine is located eight miles in a northerly direction from the village of Marmora, upon a public road and within half a mile of the terminus of the new railway now being constructed by the Belmont Bessemer Ore Co., which owns the iron mine situated on the adjoining lot.

The company has nearly completed a mill plant in the village of Marmora of 12 tons capacity (or four mills of three tons each) in 24 hours to be run by water power, known as the Crawford process, to test the ore. The Crawford process has been on trial for several months past and these mills have proven to be eminently successful in the treatment of low grade gold ores. The company purchased the patents for this process at a cost of $500,000, and is now manufacturing the mills in London, England; several are in use in California, and a large number have been sent to South Africa for use in the company's mines and by others operating the gold mines of that country.

The introduction of this new mill for the treatment of low grade gold ores and the opening of this extensive gold mine may impart new life to the entire gold bearing regions of Marmora and Madoc.

LOCATIONS IN FAIRBANK AND CREIGHTON.

The Canadian correspondent of the Financial and Mining Record, published in New York, referring to gold properties in Ontario writes as follows in the October number:

The syndicate represented by Mr. J. M. Clark are sinking a 100-foot shaft with two drifts on their gold location in Fairbank. They have traced and stripped a vein along the top of a bluff for nearly 600 feet, then down the face of the bluff nearly 100 feet. Near the base of this bluff a quantity of gold ore was blasted and crushed, the result averaging $15 to the ton. The vein is between four and five feet wide. According to the opinion of a Chicago expert ore of the character here found can be reduced for $3 per ton. Gold has thus far been traced across part of Creighton, all of Fairbank and into Trill township, a length of about twelve miles.

The Fairbank Consolidated Mining Company with a capital stock of $500,000 owns 1,150 acres in the townships of Fairbank, Creighton and Trill in the Sudbury district. Toronto gentlemen are the officers of the company, including Messrs. Henry Lowndes, O. A. Howland, J. L. Nichols and others. The company have opened up three different veins and are awaiting the result of the milling test. One assay of a piece of surface ore showed $22 of gold to the ton. The veins are very promising on or near the surface. I am informed that the company is about to dispose of a section of its property to an American syndicate.

A correspondent of the Toronto Globe writes from the Sudbury district as follows:

A number of men have been engaged cutting roads for taking provisions, lumber, etc., from the railway to the mineral properties in Trill, Fairbank and Creighton. A mining expert who has been investigating the districts in the vicinity of Vermilion and Gordon lakes, and who has had extensive experience in the mines of the United States and Mexico, states that several of the quartz veins in the township of Fairbank very strongly resemble the Homestake mines of the famous Black Hills country.

SILVER.

The silver mines of the lake Superior country have been worked more generally throughout the year than heretofore and some of them on an extensive scale. Towards the end of the year however a report gained currency which for a time seemed likely to seriously depress the value of mining property in that district, viz.: that in the lower beds of the Animikie formation the veins carried so little silver as to hardly pay the cost of working. This report was strengthened by the action of the Beaver Mining Company in closing its works, and although this company published no statement there were many who thought that the shutting down of the mine had no other explanation. On this subject Mr. Walpole Roland, M.E., of Port Arthur, reports that one or two of the new lodes now being operated in the lower beds, including the Empire, are proving to be richer than lodes situated in the upper or true Animikie series. The only difference between the upper and lower beds, Mr. Roland says, is that the latter is more silicious and consequently carries less clay than the former. From personal examination he writes as follows:

Beginning with the Empire lode on the north half of lot 2 in the second concession of O'Connor township, the occurrence of this interesting discovery of black and native silver in view of the conflicting opinions and theories of latter-day scientists is of more than ordinary moment. There at a point 220 feet below the main tunnel of the famous Beaver mine, three-quarters of a mile away, and at a point approximately corresponding with the appearance of the lower series of the Animikie slates or cherts in that mine, we find the Empire's openings producing rich silver with excellently defined true fissure veins that so far as can be determined from the present stage of development (viz.: 21 feet deep) and the general appearance of the gangue of the lodes give great promise of continuity in depth. It is also significant to note that the Beaver Mining Company through its zealous agent and manager, Captain Hooper, has already solved this important problem and proved by actual work and tests that of the two series of beds the lower is the richer, as may be inferred from the large shipments from that mine as well as from the promising characteristics at the Empire and other well known lodes similarly located. . . . There now exists very little difference of opinion among practical mining men as to the lower beds being as rich as if indeed not richer than the upper, as latest shipments of silver ore from this immediate vicinity fully demonstrates. The other notable occurrences of rich silver in this formation include the Gopher and Star mines north of Whitefish lake, and the Silver Centre (R 83 and R 64) near the Crown Point mine on Silver mountain. These two locations, 88 and 64, occupy the same relative geological position to the Crown Poin mine that the Empire mine does to the Beaver. They are immediately below the working of the Crown Point and are traversed by the same strongly defined lode. R 88 whereve tested in the lower beds there prevailing invariably shows silver abundantly.

MURILLO MINE.

The Murillo mine was visited in July. Work on this mine had been suspended fo about one month previous to my visit. The property had been worked with a forc of 16 men from December 1st, 1890, to about the middle of June in the current yea under the management of Mr. John S. Winter. The new boiler and pump referred to i my first report had been placed in position and extensively used. The result of th operations of this mine since my former report was as follows: The shaft was sunk to th depth of 135 feet, an increase in depth of 49 feet, and two levels have been run in. Th first, 60 feet from the surface, extends a distance of 75 feet in a southerly directio following the vein, which was well mineralized, carrying an average of 15 ounce of silver. The second level was at a distance of 123 feet from the surface and has been driven in 25 feet in a southeast direction following the vein matter, which was mor broken than in the drift above; it also carries a less percentage of silver.

Four test pits have been opened; the first northwest of the shaft 100 feet and sunk to the depth of 12 feet, opening up the vein; the second and third test pits are 100 feet apart in the same direction and have been sunk 8 and 10 feet respectively; the other opening southeast from the shaft has been sunk to the depth of 22 feet in barren rock.

Mr. George Sowman, assayer, had charge of the property. Considerable water was standing in the mine. I have learned since my visit that this property has been put on the market.

The St. Joseph mine on the adjoining lot is still lying idle.

THE BEAVER MINE.

This mine has been constantly worked and the mill running since my previous inspection.

Additional work has extended the upper level a distance of 53 feet. Number 4 level has had additional extension to the north 66½ feet and south 21 feet. Number 3 level has been run in an additional length of 96 feet. New work on the cross-cut vein has reached a distance of 106 feet east and 80 feet west. The winze in the bottom of No. 4 level has been extended 10 feet.

The output of the mill rock averages 20 tons daily or 520 tons per month, equal to 8,000 cubic feet monthly. In addition there would be removed from the stopes as much more of refuse or barren rock not taken to the mill. This mine is kept in first-class order and is worked with remarkable economy.

In the mill another one of the old Frue vanners has been removed and a Hooper vanner substituted. There are three of the old and four of the new vanners used now. The mill is running to its full capacity and the concentrates sustain the usual high percentage of silver.

A new opening has been made at a distance of one-quarter of a mile east of the Beaver mine on the company's property known as the North Bluff. A drift has been run in from the side of the bluff a distance of 600 feet in an easterly direction, and at the distance of 300 feet from the mouth of the level the drift taps the ore and follows the vein matter. From this working about 50 tons of ore have been sent to the mill and 50 tons are lying on the dump. This new opening indicates that a large body of milling ore is accessible.

THE BADGER MINE.

The Badger mine (comprising the old Badger and Porcupine) has been constantly worked throughout the year. About 80 men are employed. All the works are in good condition, under the management of Mr. Herbert Shear.

But little work has been done on the old Badger vein during this year, most of the work being confined to the Porcupine and the new vein mentioned in my report for 1890.

On the new or No. 2 vein a shaft has been sunk 150 feet deep and about 800 feet of drifting done on the vein. Developments on this vein have been quite satisfactory, the ore all being of a good milling quality, with a considerable quantity of a high shipping grade.

The Porcupine shaft has been sunk to a total depth of 130 feet. Drifting has been done both east and west at 80 feet from the surface and connection made through the hill to the west with No. 1 adit level, the total length being 735 feet from the shaft. This level has been driven east from the shaft 190 feet, making a total length of 925 feet. No. 2 level was started at 130 feet from the surface and has been driven east 130 feet and west 250 feet, making a total of 380 feet. No. 1 winze was sunk 175 feet west of the shaft, connecting the first and second levels.

Regular shipments of ore have been made from this mine during the year.

No. 3 vein on the Porcupine location has been put under development during the year. The vein is well defined and has the same characteristics as the other veins on this property. About 500 feet of drifting and cross-cutting has been done, and quite a quantity of ore of good quality produced.

Considerable prospecting has been done, particularly on No. 5 vein on the Badger location, where about 350 feet of drifting has been done on a vein which has some encouraging features; but so far no regular ore body has been developed.

The stamp mill has been running steadily since April 1st, and about 3,500 tons of ore have been treated.

THE CLIMAX MINE.

This mine was discovered in August, 1891, by Peter Young. It is on mining location 145T, and adjoins the Porcupine mine. It was sold December 1st to a syndicate in Minneapolis, and is now being put under development, 12 men being employed under the management of Captain J. M. Sinclair. Two veins have been found on the property, both of which are well defined and well mineralized, the ore being of a high grade.

WEST SILVER MOUNTAIN MINE.

This mine was visited in July. The property is now owned by Mr. Elias Drake of St. Paul, having been purchased by him about July, 1890. It has been worked constantly since the purchase. It is under the management of Capt. William Rapsey of Port Arthur, with a force of 25 men. Since my first inspection the water has been pumped out and shaft No. 2 has been sunk to a further depth of 55 feet, reaching a total depth from the surface of 105 feet. The timbering and ladder-way have been repaired in the shaft.

The first drift at a depth of 37 feet from the surface has been run in from the side of the mountain to intersect the shaft and extends west until its total length from the shaft is 80 feet. At the distance of 25 feet below the first a second level has been run in 72 feet west and 30 feet east from the shaft and considerable stoping done; the work has been neatly done and properly timbered. A winze is being opened between the first and second levels. A third level has been run in from the shaft at a distance of 96 feet from the surface, extending 132 feet west and 89 feet east of the shaft. At the time of my inspection most of the work was being done in this level. A large stope had been made in the west end, also cross-cuttings of about 100 feet in extent. It is the intention to continue this shaft, which has an incline of 80° north, to a further depth of 60 feet, and then run in another level. Although varying in width the vein averages 7 feet at the third level.

The ladders in the shaft used for going in and out of the mine are securely placed, but are not walled off from the part used for hoisting the rock the entire distance of the shaft. The ventilation was bad in the lowest level. I gave written instructions to have the remaining part of the ladderway walled off within 30 days, and if this did not secure proper ventilation in the lowest level, that a winze should be opened between the second and third levels. Capt. Rapsey advised me in due time that the necessary work has been done and that perfect safety is assured to the workmen, and free circulation of air obtained in this part of the mine. A new shaft has been sunk to the depth of 80 feet, but was not used and was nearly filled with water. Good steam power is used at the mine.

A shipment of 12 tons of high grade ore to Omaha had been made about the beginning of July; previous shipments of excellent grade had also been made.

GOPHER MINE.

The Gopher mine is situated about 8 miles from the West Silver Mountain mine, two miles from Whitefish lake and about 5 miles from the Port Arthur, Duluth & Western Railway. A force of five or six men has been employed in opening up the property. I have been informed that machinery was procured and placed in the mine.

THE AUGUSTA MINE.

This mine is situated on lot 1 in the first concession of the township of Strange, one mile southeast from West Silver Mountain and 1½ miles south of the P. A. D. & W. Ry. There is a good waggon road via West Silver Mountain from the mine to the station, a distance of 2½ miles. At the time of my inspection in July Mr. Wm. H. Brandon, superintendent of the mine, was working with a force of 12 men. The property is owned by Silas Griffin & Co., of Port Arthur, who have been the owners since July, 1880. The principal part of the work on this property had been done within the preceding six or seven months, and consisted of drift No. 1 on the north side of the escarpment run in a distance of 100 feet on the vein matter, which is well mineralized and carries some silver. The vein is between slate and trap formation. The end of the drift is about 100 feet from the surface. Level No. 2 is driven in a distance of 240 feet, starting at a depth of 150 feet from the entrance of the first drift and following the vein matter in the same direction. At a distance of 125 feet from the mouth of this drift a cross-cut has been made in a southeast direction with a view of tapping the main lead, which was expected to be reached at about 30 feet. This drift and the cross-cuttings are in slate and solid formation, and no timbering is required for the safety of the workmen. A good boarding house and seven other buildings have been constructed for the convenience of the workmen.

SILVER BLUFF MINE.

This property is situated three-quarters of a mile west from the Augusta, on the location known as "Silver Bluff." It is owned by parties residing in Minneapolis, Minnesota, and had been worked for only three weeks with a force of 5 or 6 men under the charge of Mr. Walter Middaugh of Port Arthur, formerly of Grand Rapids. The work so far consisted of clearing the surface and doing test driftings; from the sample shown it may prove a productive property.

EAST SILVER MOUNTAIN.

This mine is known by the name of Shuniah Weachu. Work has been constantly carried on since my last visit of inspection with a varying force of from 20 to 50 men under charge of Capt. Henry James. Mr. Arthur McEwen is the mining engineer.

Additional work has been done on the main shaft in sinking it another 50 feet; the total depth is now 750 feet. Work has been suspended in the bottom of this shaft, and it was partly filled with water.

A cross-cutting was being made in the first level, 100 feet from the surface and about 150 feet from the shaft, the extent being 25 feet. Two men were engaged at this work.

A new shaft had been sunk at the foot of the mountain to the depth of 54 feet at a distance of 300 feet from the mouth of the old drift. Work was suspended in this shaft on account of water. At the same point a new drift had been run into the mountain a distance of 200 feet west, following a vein of good milling ore for the entire distance in slate formation. Timbering was required for only a short distance in this drift.

A new discovery of ore was made at the distance of 300 feet from the mouth of the second old level and a drift following the lead for 50 feet had been made and a considerable quantity of valuable ore taken out. Four men were employed on this lead.

Another important discovery had been made a few days before my visit, distant 700 feet from the first new find. Work was being vigorously pushed at this point, and the vein showing exceeding richness in native silver had been uncovered 50 feet. The hanging wall is slate and the foot wall quartz.

Assays were made showing from 300 to 5,000 oz. per ton. Several valuable nuggets of silver had been collected from the rock at this time. I have been informed that a large quantity of valuable ore has been obtained from these workings.

CROWN POINT MINE.

Crown Point mine has been lying idle throughout the year, otherwise than being kept in good condition.

SILVER CENTRE MINE.

Mr. S. J. Dawson has by several cross-cuttings opened some rich ore in the Silver Centre mine, which is in fact an extension of the Crown Point lode.

PALISADES MINE.

This property is situated 5 miles east of the Shuniah Weachu, and on the public road leading to Murillo station. It is owned by Mr. Walter Middaugh and was being worked with a force of 4 men under the supervision of Mr. Winchell, an American geologist, who is also interested in several other mining properties.

A drift had been run in from an incline below the high ledge of rock a distance of 150 yards through a clay deposit and was well supported by timber. The perpendicular bold cliff had been penetrated to a few feet when the vein matter well mineralized was tapped.

From recent reports of this mine it appears that a considerable quantity of valuable ore has been taken out.

THE LILY OF THE VALLEY MINE.

This is a discovery of ore of exceeding richness in native silver, and carrying some copper and galena. It is situated on lot 19 in the second concession of the township of Paipoonge, 11 miles from Fort William and 16 miles west of Port Arthur. It has led to further exploration, and the vein has been traced and uncovered on the two adjoining lots east and west.

The rock formation is quartz and slate, the latter cropping out at the surface. The discovery was made in the fall of 1890, but silver was not found until June, 1891, in an opening made on a small elevation covering an area of two or three acres. Four distinct veins had been uncovered, showing valuable mineral stretching a distance of 200 yards. A keen interest has been awakened throughout the community and a large amount of prospecting done, and this discovery may prove to be a fine mineral field in this old settled part of the township. The property was discovered by Mr. Henry Parsons, who retains a three-eighths interest. One-eighth is owned by Mr. John Woodside and one-half by Mr. W. J. Barry, all of Port Arthur.

NICKEL AND COPPER.

The nickel and copper mines of the Sudbury district were less active during the past year than the former one, but although the quantity of ore raised was less the furnaces were steadily employed and a large amount of matte was disposed of at fair prices. The United States Government having after a series of tests demonstrated the superiority of an alloy of nickel and steel for the armour of battle ships, decided to adopt that armour for all vessels under contract, and under an appropriation of Congress the Secretary of the Navy purchased last year 4,536 tons of nickel matte containing about 900 tons of nickel for this purpose. The whole of this matte was supplied by the Sudbury furnaces, and smelting operations were active throughout the greater part of the year. The results of experiments carried on by officers of the British Admiralty are not as well known as those of the United States, and it was late in the year before any decision was arrived at. The only information respecting it is contained in a memorandum published by Lord George Hamilton for the guidance of the Imperial Parliament in voting this year's supplies for the Admiralty, in which he says:

> Nickel steel has been experimented with largely. Four firms have succeeded in producing successful specimens of thin armour of this quality; while two firms have manufactured 10½-inch nickel steel plate, some of which well combined resistance to perforation with freedom from serious cracking and compared favorably with nickel steel armour made abroad. Extensive orders have been placed for nickel steel armour, forming the secondary defence of the battle ships now in progress. Several ships are either fitted with this kind of armour, which has been proved sensibly superior to ordinary steel when used in thicknesses of 3 or 4 inches. For greater thicknesses the experimental results do not at present place nickel-steel in so good a relative position; but the enquiry is still incomplete. So far as it has gone it has proved that British armour plate manufacturers are keeping pace with the manufacturers of other countries, and the information will be of the greatest value when deciding on the armour to be used in future ships.

On the whole there is reason to look with confidence to a growing demand for nickel not only for use in the production of armour plate, but for a great variety of other uses in the industrial arts.

COPPER CLIFF MINE.

I visited the Copper Cliff mine late in July, and found that work had been suspended since the beginning of the year, with the exception of keeping it in a state of good repair.

One of the smelters was running and the supply of ore on hand I was informed was ample to keep the smelters running to their full capacity for a year; about 125 tons were treated daily. When the ore is required the work in the mine will be resumed on a scale sufficiently large to supply the smelters. Among the material improvements being made at the mine was the enlarging of the rock house to double its former size, but considerable time would still be required to complete this extensive work.

The new building which was in process of erection for the re-treating of the matte when I was last at the mine has been now completed, and the three converters and the new furnace for melting the matte have been placed in position. By this process of re-treating the matte it will be raised to double its former richness before shipment, thereby saving much expense in freight and greatly increasing the value of the product. The final process of refining will also be greatly cheapened.

A notable process has been invented and placed in operation at the smelter by Mr. McArthur, who has charge of the smelting department, for disposing of the slag. It is drawn off from the water-jacketed furnace in a continuous stream into a spout by which it is conveyed a short distance from the smelter and emptied into a large water tank; from this it is lifted by a chain elevator in a granulated state and poured into a lateral worm conveyer, carried a distance of 150 feet and dumped into a pile. This product although counted of no commercial value will probably eventually be used by mixing it with other suitable material for constructing macadam and concrete roadways, pavements, etc.

The large quantity of matte on hand at the time of my previous inspection had been since shipped to a profitable market. The working force had been reduced from 300 to about 100 men.

THE EVANS MINE.

Work on this mine has been suspended, as in the case of the Copper Cliff, but will be resumed when ore is required for treatment at the smelters. All about the mine is kept in good condition.

THE STOBIE MINE.

The Stobie was being worked with a force of 18 or 20 men under Capt. William Blewett. The principal additional work done was at the mouth of the adit in opening a pit 60 by 100 feet and 35 feet in depth, from which had been taken nearly 9,000 tons of ore. The ore after being carefully sorted is hauled over the railway track to the ore beds near the Copper Cliff smelters. This road was graded by the company and the rails laid by the C. P. R. company. The repairs are done by the mining company. I noticed 25 or 30 tons of high grade copper ore which had been sorted for separate treatment.

THE MURRAY MINE.

The Vivian Company which owns this property placed the management of the work in the hands of Mr. George N. Hendrickson, formerly of Norway, in March last; the previous year he was the cashier for the company.

The shaft formerly reported as the Vivian is now designated shaft No. 6, and is sunk to the depth of 100 feet.

At the 60-foot level the northeast drift has been extended 94 feet, the whole length now being 184 feet, in which extensive stopes have been made leaving an opening 50 feet long, 40 feet wide and 20 feet high. The southwest drift from this level has been extended a distance of 40 feet, making a total distance of 100 feet; in it a stope of 40 feet in length, 45 feet in width and 20 feet in height has been made. From the north end of this stope a drift has been run in westwardly a distance of 20 feet, and from its extremity it is intended to sink a winze to the level below. At the bottom of the shaft a drift has been run in westwardly 28 feet; about the centre of this drift another drift of 8 feet has been started following the lode in a southerly direction which was to be continued, and at the further distance of 30 feet would intersect the winze above mentioned from the upper drift. The surface workings at this mine have been carried on extensively both northeast and southwest from the shaft, from which upwards of 4,000 tons of ore have been removed and hauled to the ore beds.

The smelter was undergoing important changes and it was expected it would be in full operation again in about a month. This department of the work is under the management of Mr. W. Edwards, formerly of England, who has held this position since the beginning of the year.

Former shipments of matte from this smelter had reached to 8 per cent. of nickel. By the use of the converters it is now raised to the standard of 35 per cent. through the bessemerizing process being applied to the nickel matte. A few thousand tons of roasted ore were on hand ready for the furnace, and a considerable quantity in process of roasting.

The additional buildings consist of a new residence for the manager and a few houses for the workmen. An excellent rock house is being constructed. The working force has now reached about 200 men.

THE BLEZARD MINE.

The present depth of No. 1 shaft is 172 feet below the crown of the hill, and at the bottom a drift has been run in 60 feet to the northeast and from the end of the same stoping has been commenced.

The rock roof over the extensive excavation referred to in my former report has been partially removed, showing a thickness varying from 18 to 27 feet, and a good view of the interior workings can now be had from the surface, which tends to confirm the previous description and proves the safety of the work at the date of my former report.

The pillars of ore which were left to support the rock roof are still in place and will be removed as the ore is required for use.

A new shaft, called No. 4, northeast of the old workings, has been sunk to a depth of 65 feet and is in ore nearly all the way down. Some additional outside improvements have peen made, and a working force of 200 men is employed.

The smelter was in operation, treating about 125 tons daily. The matte as fast as made is sent to market.

THE WORTHINGTON MINE.

Work on the Worthington property has been steadily progressing throughout the year. Shaft No. 1 has reached a depth of 35 feet. Shaft No. 2 has been sunk 95 feet; from this shaft a southwest drift has been run in 60 feet and a northeast drift to the distance of 50 feet. The former drift is intended to intersect shaft No. 1, which will be sunk to a depth to meet it. This work is necessary to secure proper ventilation in the mine, which in this respect I found to be bad. Better facilities were required for getting in and out of the mine. The necessary changes to remedy this were to be completed at an early date.

A shipment of 70 tons of first-class nickel ore was recently made to England, and a shipment of copper ore to the United States.

A roast heap of first-class nickel ore similar to that shipped was being prepared for smelting at the Blezard furnace. Considerable ordinary grade ore is being taken from this mine and regularly roasted and sent to the furnace. The working force at this mine is from 15 to 20 men; a boarding house and other suitable accommodations are provided for the workmen.

Late in the year work was suspended on the Blezard, and it is reported that a sale of this mine has been made. In a recent issue of the Toronto Daily Globe reference is made to this as follows:

> This property has been purchased by an English syndicate at the price of £400,000 sterling. The mine for the coming year will be operated on a much more extensive scale. The plant will be increased and the most modern machinery and appliances introduced. Less than five years ago this property was offered to a Toronto syndicate for $28,000. Machinery was put on the property and enough metal was sold previous to this sale to recoup the owners their entire expenditure for property, machinery and development. This price of $2,000,000 is the largest price ever paid for mining property in Canada.

The report of this sale has been confirmed by other publications, but up to the present time no formal notice of the change of ownership has been received by me under "The Mining Operations Act," section 12 of which provides that this shall be done within two months from the date of the transfer.

THE CHICAGO NICKEL MINE.

This property is situated on lot 3 in the fifth concession of Drury, four and a half miles north from Worthington station on the Sault Ste. Marie branch of the C. P. R. It was purchased by the present owners in 1890, and work was begun in February last, a force of 20 men being employed in the construction of roads and buildings and doing development work. I found a force of 12 men at work under the management of Mr. Thomas Travis, one of the owners of the property, with Mr. Alexander Strom as foreman. Work had been constantly carried on since its commencement. An opening has been cut on the surface of the hill for a distance of 200 feet following a vein of nickel ore varying from 8 to 20 feet in width. The depth of the cutting for a considerable distance is 20 feet. At the crown of the hill, about midway on this opening, a cross-cut has been made 15 feet north in ore the entire distance; 200 feet east from the east end of the main opening above described, on the opposite side of a small ravine, a shaft was being sunk with the view of tapping the vein, the depth reached being 15 feet. About 3,000 tons of ore were on the dump, and I was informed that frequent assays had determined its value to be as high as 7 or 8 per cent.

A steam drill has been in use from nearly the commencement of the work, and it is the intention of the company to push the work rapidly and determine by actual development the value of the property. Should bodies of ore in sufficient quantities be opened a smelter will be constructed at the mine for its treatment. The present indications are that this property will prove to be one of great value at no distant date.

A good winter road has been made from the Worthington station to the mine, which is now used for carrying in supplies. An easy grade is available over this road for the construction of a tramway.

One and a half miles north of the mine is situated the beautiful Fairbank lake, three miles in length and three-quarters of a mile in width, to which a good road has been constructed and from which an abundant supply of ice is obtained for summer use at the mine. There is within 100 yards of the mine a living stream of pure water sufficient to supply all the water that may be needful for a smelter and other uses at the mine.

OTHER LOCATIONS.

Several nickel properties have been opened and worked to a limited extent in the Sudbury district, some of which I was unable to visit. I have been informed that in the early part of the year openings were made and development work done to the extent of $500 or $600 on lot 12 in the third concession of Denison, 1½ miles from Worthington station and three-quarters of a mile from the railway track. A vein was opened which showed but two inches of ore at the surface and widened to two feet at a depth of four feet. From it was taken what is said to be a new mineral for Canada (Gersdorffite), assays of which reached 55 per cent. of nickel. Analyses of 20 European samples given by Dana give an average of 29.77 per cent. nickel, ranging from 19.59 to 40.97 per cent. The Sudbury vein has been traced over 100 feet on the hillside.

On lot number 11 in the fifth concession of Lorne township development work has been done in opening shaft No. 1 to a depth of 35 feet; shaft No. 2, 22 feet; shaft No. 3, 15 feet; shaft No. 4, 12 feet, and several smaller openings. About 500 tons of two per cent. ore is now lying upon the dump. This mining location contains 261 acres and is situated one and a half miles east of Nelson station on the Sault Ste. Marie branch C.P.R. and is 31 miles west of Sudbury. The property will be worked later in the season by the Algoma Nickel Company which has made an option purchase of it.

On lot 7 in the second concession of Levack work has been done by sinking several shallow test pits at intervals over a few hundred feet. One surface drift has been extended up the mountain side 125 feet, uncovering ore the entire distance along the contact of diorite and syenite rock. Over 100 tons of low grade nickel ore carrying a small percentage of copper have been taken out of the works. This property was purchased after a careful examination for an English company by Mr. Huntington, who accompanied the members of the Iron and Steel Institute on their visit to the Sudbury district, and embraces 240 acres.

Lot 6 in the second concession of Levack, containing 160 acres, was also purchased by the same company at the same time. Work has been done on this property by stripping the ore and sinking shallow test pits over an area of 120 feet in length by 80 feet in width. A large quantity of ore has been exposed of similar grade to that described on the former property. About 100 tons are lying on the dump. These properties are about 4½ miles from Onaping station, on the main line of the C. P. R., 24 miles west of Sudbury.

Lot 2 in the fourth concession of the same township, 6 miles from Onaping station, contains 160 acres, and is owned by the same company. Test pits have been sunk on the northwest corner of the lot at short distances apart over about 10 acres, showing an abundance of mineral. From these openings a few hundred tons of ore of similar grade to that found on lots 6 and 7 have been raised. On the east side of this lot eight test pits have been sunk, stretching a distance of 150 feet; the result is an excellent showing of mineral. A small dwelling house and a blacksmith shop have been built.

A good winter road has been made to these several properties, and two sample car loads of ore have been sent to England for treatment.

On lots 5 and 6 in the third concession of the same township Mr. Babcock and others of Sudbury have done considerable test work with good results. Openings have been made with excellent showings, the assays reaching 4½ per cent.

On the south half of lot 4 in the fourth concession of the same township similar results have been obtained by test workings. The expenditure on the Babcock properties in th early part of the year was about $800.

Dr. Robert Bell in the recent report of his geological survey of the Sudbury district says:

> Other metals, including gold, platinum, tin, lead, silver, zinc and iron, have been found in the Sudbury district, and probably some of them may prove to exist there in paying quantities. The presence of a considerable proportion of nickel in the ore of the Wallace mine, on the shore of lake Huron and in the strike of the Sudbury deposits, was ascertained by Dr. Hunt more than forty years ago; yet the presence of this metal in the latter does not seem to have been suspected for a considerable time after they had been worked for copper alone.

The October number of the Engineering and Mining Journal of New York contains a dispatch from Ottawa which says that nickel-bearing ore has been found on the farm of G. S. McFarlane, 19 miles from Ottawa. "Samples analyzed at the office of the Geological Survey in Ottawa are said to have proved to be as rich as the best ore of the Sudbury district."

Mr. J. Cozens of Sault Ste. Marie writes to me of recent date regarding his Michipicoten copper mine as follows:

I have done a certain amount of surface exploring, finding heavy bodies of native copper, but have done no mining in depth. I have kept everything in first-class order and looked into the question of my water power, which I hope to develop for mining and milling purposes early next season. I have an inexhaustible supply of water and 228 feet head, so I think that I can mill copper now cheaply.

Of copper ore Dr. Robert Bell in his report above referred to states:

The Huronian is notably a copper-bearing system. West of Sudbury, in the great belt we have already traced, this metal occurs around Batchawana bay, north of Sault Ste. Marie, at little lake George and Echo lake, at Huron Copper bay, in Wellington and Bruce Mines, on Thessalon and Mississaga rivers, and elsewhere. To the northeastward it has been found on both sides of lake Wahnapitae, on Temagami and Lady Evelyn lakes, along Montreal and Blanche rivers, on the watershed east of the canoe route between lakes Temiscaming and Abittibi, and finally near the southern extremity of lake Mistassini. The search for this metal along the Huronian belt, which has been described above as running for more than 600 miles, is only in its infancy, and the copper-mining industry may some day be very extensively carried on in various parts of this, as yet, almost unknown section of Canada.

THE SMELTING OF COPPER-NICKEL ORES.

I herewith subjoin an article of much interest to Canadian investors in copper and nickel properties in Ontario taken from the Canadian Mining Review of Ottawa, December number, page 253, containing excerpts from the second edition of the work of Dr. E. D. Peters, jr., on Modern American Methods of Copper Smelting, in which he also discusses largely the treatment of nickel ore and nickel matte.

Dr. E. D. Peters, jr., well-known to Canadians as the first manager of the copper-nickel mines of the Canadian Copper Co. at Sudbury, where he demonstrated the feasibility of smelting these ores on a large scale in water-jacket furnaces, has issued through the medium of the Scientific Publishing Company, New York, the second edition of his well known and widely read work, "Modern American Methods of Copper Smelting." The book, apart from its great value as a reference to metallurgists generally, is of particular interest to Canadians, inasmuch as it contains the latest addition to the literature of nickel metallurgy. As Dr. Peters assisted in the opening of the mines, and the first smelting works were built under his direction, he speaks authoritatively of such matters as came under his personal observation, and within the sphere of his own practice. A few excerpts from his references to the mining of the nickel in this country will not be out of place:

"On an average the ore treated at the principal mines carries some 4 per cent. of copper, though if selected it could easily be brought up to 8 or 10 per cent. But up to the present time experience has shown that it pays about as well to mix all the ores and smelt them as they are as to try to make two grades of matte, one rich in copper and poor in nickel and the other high in nickel and low in copper. By pursuing the latter course a slightly better price can be obtained from the refiners, but the metallurgical operations are seriously embarrassed, as if the heavy nickel ore is smelted alone it produces far too basic a slag; while if the richer copper ore is fused by itself the slag is too silicious to smelt easily. By mixing the two varieties of ore in their proper proportions a good slag is obtained without the addition of flux, not a pound of the latter being used during the time I was in charge of the work. Besides, the ores roast much better when mixed than if separate."

Dr. Peters then fully describes the methods of roasting the ore, in which he calls attention to the vital importance of having a proper and well-drained roast ground.

"In the severe climate of northern Ontario it was sometimes necessary in inaugurating a new plant to build a heap on frozen ground, or ground that was not thoroughly drained. In both cases the results were miserable, the escaping steam seeming to completely impede the combustion, and the resulting heap when torn down revealing isolated spots, each containing many tons of ore that were not roasted at all, only the surface being slightly scorched, though the greatest pains were taken in building and managing the heap."

He points out that an absolutely dry and unfrozen ground is essential to success, and if snow falls it must be carefully cleared away before laying the wood down, and after the wood is once in place no snow or rain must fall upon either the fuel or ore. Where the ground is frozen the results of the roasting are always unsatisfactory.

"A few hours after lighting the heap, water begins to flow out from under it, and for day or two a continuous stream will pour out from the lower side of the pile, generating steam in quantities and extinguishing the fire as soon as the lumps of ore are scorched a little on the outside."

Dr. Peters then goes on to discuss the treatment of the nickel-matte, and the subject is so attractive that we cannot refrain from giving his remarks in full:

"In nickel smelting, when the matte is obtained it still remains to be refined, and only those who have been through such an experience realize the difficulties of disposing of it.

"In the first place it becomes a question of calculation whether it will pay better to ship the matte at about a grade of 25 per cent. as it is produced from the furnace, or to concentrate it on the spot by a second series of roasting and smelting operations. Until the local conditions, wages, scale on which operations are conducted, exact character of ore that is treated, etc., are known, this question cannot be answered. The matte is enriched by roasting it and resmelting it in a water-jacket or other furnace, with quartzose flux to take up the iron. It is a question to be determined by circumstances whether the roasting should be executed in heaps, as with the ore, or whether it should be crushed and calcined in a few hours in calcining furnaces. Heap roasting of matte takes about as long as the ore, because it has to be re-roasted two or three times, as it does not roast freely like the ore. But as there is only about one-sixth so much to handle as the raw ore, the expense per ton of ore is not heavy. A matte of about 50 or 60 per cent. of nickel is produced by the so-called concentration smelting.

"This concentrated nickel matte has a high point of fusion, and easily forms crusts and accretions.

"It is impossible to smelt it in a furnace with brick fore-hearth, as may be advantageously done with the ore, for it soon fills up the front crucible, necessitating its substitution and leaving a 'salamander' weighing a ton or two that is difficult to break up.

"After much experimenting I have returned to the old practice of using 'steep,' or a mixture of pulverized coke and clay, for a fore-hearth, cutting in it a small crucible connected with the furnace crucible by a deep groove. Out of this crucible the rich nickel matte can be either tapped or ladled into moulds, and as this method of procedure involves frequent though very slight repairs it will save much delay to make the fore-hearth broad enough to permit of two such crucibles, side by side. Thus one can be repaired and dried while the other is in use.

"The further treatment of the nickel matte, according to the old practice, is well known and its description would be out of place in this connection.

"Being expensive and slow, efforts are being made to improve upon it, and one of the principal nickel-smelting companies at Sudbury is erecting a plant to bessemerize this rich sulphide of copper and nickel.

"According to the laws of chemical affinity, as modified by the high temperature employed, we know that the iron still remaining in the matte ought to oxidize first, forming with silica a slag that may be poured off. Next, the nickel should oxidize and slag away, leaving behind the pure copper. But whether such accurate results will be reached in practice seems to me somewhat doubtful.

"In the bessemerizing process as applied to iron the entire mass of metal remains homogeneous throughout the operation, the impurities being gradually oxidized until it is all converted into steel. And the total amount of these impurities is only four or five per cent., so that the mass of fluid metal operated upon is not perceptibly lessened.

"But in bessemerizing a mixture of the sulphides of iron, copper and nickel the number of different chemical compounds having differing specific gravities and tending each to form its separate stratum in the converter, is too great to even enumerate.

"As soon as sufficient sulphur is removed to correspond to the iron present, we shall have a layer of oxide of iron (combined with silica from the converter lining) on top, while below the sulphides of nickel and copper will remain comparatively unaltered. Then may come a period when we have the same silicate of iron on top, followed by a little silicate or oxide of nickel, whilst some metallic nickel has formed and sunk to the bottom, and the rest of the nickel, in its original condition of sulphide, forms a stratum below the unaltered sulphide of copper.

"These reactions and products increase in number and complexity as the operation advances, and remembering the great difficulties encountered in bessemerizing even so simple a substance as copper matte one cannot help feeling some curiosity as to the practical success of this operation.

"That nickel and copper can be rapidly reduced from the condition of a matte to that of separated metals, the author has convinced himself. But business considerations prevent the further elucidation of this subject.

"The final treatment of the nickel-copper alloy, or of the already separated metals, does not fall within the scope of this work.

"But it must be evident to every one familiar with the facts that the commercial electrolysis of copper on the one hand and the electrolytic deposition of nickel in our nickel-plating establishments on the other hand point out a path to follow that is too plain to be neglected.

"And as our chemists find no difficulty in precipitating with the electric current chemically pure copper from a solution containing both copper and nickel, and then, by slightly altering the conditions, precipitating all the nickel in absolute purity from the same solution and with the same current, it would seem that our refiners might reasonably expect to effect the same results on a commercial scale, especially as there is practically no loss of acid in the operation.

"Nor can I see any reason why nearly all our metallic nickel should be offered to the trade in little cubes less than an inch square. Of course this peculiar form has resulted from the practice of the nickel refiners to reduce the oxide of nickel obtained by the methods now in use to metallic nickel. Being mixed with rye meal as a reducing agent it is formed into these little cubes, and a number of these packed in crucibles are exposed to a sufficient heat to reduce the nickel to a metal without fusing it. This makes a small porous fragment of metal suitable for solution in acids and where nickel is to be used in minute quantities. But it adds materially to the expense of refining, and there is really no more reason why nickel should be so treated than copper or iron.

"Although the fusion point of nickel is rather high, yet a sufficient temperature to make nickel pour as readily as copper is obtained without difficulty in metallurgical practice, and there is little doubt that before long nickel will be refined in bulk and cast into suitable ingots, as is copper or lead.

"Indeed at Vivian & Company's nickel works in England a small reverberatory heated by gas has been in use for several years for refining nickel, some 2,000 pounds being refined at a charge; and the superb display of solid nickel articles and ingots made by Joseph Wharton of Philadelphia shows that he experiences no difficulty in melting and casting nickel like other metals.

Another feature of Dr. Peter's book of interest to Canadians is the detailed plan of the large reverberatories now being constructed by the Eastern Development Company at their mines at Coxheath, C. B. These drawings cover nine full size pages, and probably form the most complete and detailed working drawings of a modern reverbatory furnace that have yet been published. They are accompanied by exact estimates of the cost of every detail of the furnace. The book is nicely gotten up and in every sense merits the careful attention of everyone interested in the metallurgy of copper.

IRON.

The extensive iron belts in western Ontario have not been worked during the year 1891, but the limited prospecting carried on has confirmed the wide area over which the deposits extend and the richness and purity of the ores. The Atik-okan district has attracted the special attention of foreign capitalists, and large investments are reported to have been made. The Weekly Herald of Port Arthur of December 15th reports as follows:

ORE DEPOSITS LEASED BY THE BELGIAN BANK.

Ferdinand Vanbruyssels, Belgian Consul-General for Canada, left for home to-day accompanied by Messrs. Wiley and Russell of Port Arthur. Before leaving he succeeded in closing contracts for the Belgian Bank of all known ore deposits on the Atik-okan iron range, covering an area in length of twenty miles. They propose mining there, building the Atik-okan railway, and erecting blast-furnaces, rolling mills and other iron industries here. The Canadian Pacific will lease and operate the railway, which will be sixty miles in length.

BELMONT IRON MINE.

This property is situated on lot 19 in the first concession of Belmont, county of Peterboro', and comprises 100 acres. The mine is owned by Mr. T. D. Leyard of Toronto and others, and was leased in March last by the Belmont Bessemer Ore Co., composed of American capitalists with capital stock of $600,000. The company has offices at 103 Bay street, Toronto, and 290 Broadway, New York. Work had been done previous to leasing the property in stripping the ore leads for considerable distances and sinking a few shallow test pits. The present occupants have made several new openings, one shaft reaching the depth of 47 feet, and have continued uncovering the vein of ore on the surface for the distance of 350 feet. One hundred and fifteen tons of ore have been shipped to Hollidayburg, Pennsylvania, for treatment, showing a grade of 61 per cent. About 800 tons of similar grade ore were on the dump at the time. Recently test borings have been made to the depths of 100, 70, 62, 60 and 30 feet respectively on the vein matter, which extends from 20 to 150 feet in width, and is free from impurities. The working force at the mine is under the management of Mr. G. L. Woodworth, and since the new company has held the property averages twelve men.

A railway at the cost of $5,000 per mile is being constructed from the mine to the Central Ontario railway, a distance of nine miles. The road has been graded to the village of Marmora, six and a half miles. The remaining part of the road will be graded and the rails laid early in the spring. Work will then be pushed forward vigorously at the mine. A commodious frame boarding-house was nearly completed, and other buildings erected suitable for working the mine on a large scale.

OTHER LOCATIONS.

On lot 16 in the seventh concession of Marmora the Crescent Gold Mining Company has opened an iron mine during the year. Development work comprised stripping the vein of ore for a considerable distance, and sinking several test pits; from one, which was sunk 20 feet, some excellent Bessemer ore, free from impurities, has been taken. Tests by analysis have shown the grade to be 62 per cent. On the adjoining lot is the Dufferin iron mine, owned by the Bethlehem Co. of Pittsburgh. A large quantity of ore is lying on the dump, but the mine has been idle for the past eight years.

Mr. H. M. Powell of Marmora owns the east half of lot 24 in the fifth concession of Marmora, on which he has done prospecting work with encouraging results. Four or five men were employed for six months in opening test pits and stripping the vein of arsenical ore. About 100 tons of hematite ore have been taken out. The property is nine miles northeast from Marmora village.

Several of the iron mines in eastern and central Ontario which have been extensively worked in former years and were largely productive, and in many cases with large quantities of ore on hand, are now lying idle.

No work has been done during the year in the mines along the line of the Kingston & Pembroke Railway.

CAUSES WHICH AFFECT THE INDUSTRY.

Speculations as to the cause of the collapse of iron mining enterprise in eastern Ontario assign various causes for it. When investment was active about ten years ago the duty on ore imported into the United States was 50 cents a ton. Several New York and New Jersey mines about this time ceased to be producers. The increase of the duty to 75 cents was not effectual to lessen importation from Spain, Africa, England or Cuba. The importation from these sources has grown with the increasing demands of the furnaces along the Atlantic coast to an average of 800,000 tons a year, and the recent reciprocal relations established between the United States and Cuba leave untouched the duty on iron ore from the important mines in that island. The increased duty had no effect to reopen those mines of New York and New Jersey, whose ores were either of inferior quality or costly by reason of the great depth of the mines. Processes for roasting ores objectionable on account of sulphur and for crushing and separating by magnetic attraction the iron oxides from the accompanying rocky material with which the phosphorus is confined have been greatly improved within the last five years, and are now economically used at mines which but for them could not be successfully operated. The use of concentrated ore in the United States foots up some 90,000 tons yearly, the output of twenty-five mills.

A paper by W. H. Hoffman, M.E., read before the American Institute of Mining Engineers at its meeting in October last gives the results attained at the Croton mines, New York, in the roasting and concentration processes. The ore, broken to pass through a 2¼-inch ring, is roasted in Davis Colby kilns at a cost of 8½ cents a ton for fuel gas; the cost of filling and discharging the kilns is 3 cents a ton; the average temperature of the roasting process is 1,250° Fah., which is reduced to 350° by sprinkling water on the ore as it leaves the kiln. A 94 h.p. steam engine operates a Sturtevant crushing mill, which brings the roasted ore into the crushed condition at the rate of 22 tons an hou By means of the magnetic separator the ore is removed from the accompanying gangu and the metallic iron ore raised from 38 per cent. to 70.6, with .018 phosphorus and 0.2 sulphur. In twenty-four hours 580 tons treated in this plant turned out 215 tons o concentrate at a cost inclusive of cost of mining amounting to $1.95 a ton.

The importance of this process to many Canadian mine owners is evident in view o the large charge on the shipping output involved in the rejection to the dump of full one-third of the ore raised. The analyses have been shown me made by the furnac chemist of an American company who mined in eastern Ontario some 40,000 tons of o for its own furnaces and then withdrew from the business with considerable loss of abandoned machinery. The mean contents shown by forty-two analyses are: metallic iro ore, 48.8; phosphorus, .013; silica, 9.34; lime carbonate, 5.8; magnesia carbonate 9.012; manganese oxide, .45; pyrites, .442. It is altogether probable that this ore coul have been materially improved by treating one-third of the quantity shipped for concentration and removal of sulphur and phosphorus, but at the time when the mine was surrendered these processes had not reached their present economic development. Doubtles some of our ores are sufficiently rich to render the process referred to unnecessary.

Iron mining in the United States within the past five years has not only show enormously increased production, but has taken in new fields, calling for capital fo development to such a degree that the question arises, Can any immediate developmen of the iron mining industry of Ontario be hoped from American enterprise?

In my former report mention was made of opinions in favor of appropriations fo diamond drill boring as a means of testing the depth and value of our iron ores. Thi method is adopted by the government of Victoria, Australia, for promoting enterprise i gold and coal mining. The report of the Secretary of Mines of that colony gives plan of the borings and statements of cost. During the year 1890 the number of bores pu down was 145, at a cost of $2.70 per foot; the total appropriation amounted to $105,000 The work could be done much cheaper in this country, and if directed by an expert woul afford exceedingly valuable information as to the depths and disturbances of our magneti ore and other ore deposits.

It has been suggested that the owners of mining properties make the cost of boring which result in important discoveries a first lien on the land.

A recent report announces that borings show an abundance of ore in the Norrie an Ashland iron mine in Michigan at 1,500 feet vertical depth.

PHOSPHATE OF LIME.

A number of phosphate properties have been lying idle during the year, or but limite operations carried on. High freight, a depressed market and heavy duties have severel checked the phosphate industry for the present.

The drop in the price of phosphate last year, which was attributed by some to th effect on the English market of a considerable importation of Florida phosphate, resulte in the suspension of mining operations at many points. The resources of the province i this mineral might be profitably investigated with the diamond drill. The late Mr. Vennor of the Geological Survey recommended the use of the drill along part of the sout boundary of Bedford township in Frontenac, and since his death other promising field have become known. The irregularity of phosphate veins or deposits and the great cos of raising the accompanying hard rock, and in some cases the expense of moving the output of the mine, have interfered with the development of this industry. Yet there i ground for believing that careful exploitation of certain known areas would result i revealing large deposits of high grade phosphate which could be profitably mined wit the application of machinery, and from which an extensive output would repay improvement in the means of transportation.

The amount brought into Kingston by the Kingston & Pembroke Railway durin 1891 was 73 car loads, 1,200 tons; from Loughborough and Storrington, 2,550 tons; i all 3,750 tons. Thirty-five tons were shipped to the United States, and the remainder t Montreal.

MONTREAL MINING CO'S. MINE.

A phosphate property owned by the Montreal Mining Co. is situated on lot 3 in the sixth concession of Bedford, at Bob's lake. Nine men were employed at the time of my visit in June who were working on royalty. A large number of pits were open, varying from a few feet to fifty in depth, and extending over an area of about forty acres. The work of this year had been but recently commenced, and in consequence only a small quantity of phosphate had been taken out. This company owns in all 600 acres of phosphate lands. Edward Nolan had charge of the work.

PROPERTIES IN BEDFORD.

Hon. Peter McLaren and Mr. Edward Watts own the phosphate mines on lots 27, 28 and 29 in the tenth concession of Bedford. This property has been worked for the past two years with a force of a few men. Six men were employed for about three months of the present year, and about 500 tons of phosphate had been taken out and hauled to Westport wharf for shipment. Four pits had been opened following the vein of phosphate, the deepest being 25 feet.

OPINICON MINE.

Opinicon or Rock Lake mine is situated on lot 21 in the fifth concession of the township of Storrington, county of Frontenac. This property is leased jointly by the Kingston Phosphate Co. of Montreal and Mr. James Bell of Arnprior, and is owned by the Canada Company. It is worked on royalty at $2 per gross ton. The work is carried on day and night with two shifts of men, a total force of 30 men being employed. Two openings were made about the middle of the lot; the larger one extends 40 feet in length and is sunk on the vein of phosphate to the depth of 150 feet. The vein increases in width from a few feet at the surface to 100 feet at the bottom of the cutting. The deepest workings of the mine had reached the level of the lake The hanging wall, which is limestone, was well supported by rock pillars which had been left. The output from this opening averages about four tons daily of 75 per cent. phosphate. It is sorted, washed and then hauled half a mile to a landing on the lake, loaded on scows each holding about 100 tons, and thence taken to Kingston. Steam power is used for drilling, hoisting the ore and pumping the water from the mine.

The second opening has reached a depth of 35 feet; the opening at the surface is 20 by 30 feet and widens as it goes down. About 1½ tons of ore of 75 per cent. phosphate is taken out daily and treated in a similar way to that taken from the other works. A whim is used for hoisting at this pit. From 6 to 8 men were employed at the working.

Mr. Neal Cochrane, a graduate of a mining school in the west of Scotland, had the immediate charge of the work at the mine, and Mr. Gorman of the Foxton mine was general manager.

Several other openings have been made on the property with excellent showing of phosphate, but they have not been extensively worked.

The whole of the work on this property was conducted in an economic and satisfactory manner.

FOXTON MINE.

Work has been continued on this mine since my visit in December, 1890. The drift 60 feet below the surface has been run in 70 feet west and intersects the stopings made from the level below. The second drift commences 100 feet from the surface and runs in west 75 feet. The stoping was still following the vein upward and had reached within 25 feet of the surface. The mineral is in a well defined vein, varying from 6 to 10 feet in width. About 30 hands were at work, drilling in the stope being done by hand. A description of the plant was given in my former report.

THE CONCESSION MINE.

The pit opened at a distance of 200 feet from the Foxton has been sunk to a depth of 50 feet, the opening at the surface being 20 by 40 feet and narrowed at the bottom to 10 by 15 feet. Three or four men were employed opening a test drift in the bottom of the pit in a northerly direction by the use of a steam drill driven with the power at the Foxton mine, which is also used for hoisting the rock.

During the winter about 600 tons of good grade phosphate were hauled to Kingston, a distance of 21 miles. About 400 tons were on hand at the mine. A more direct road of easier grade to Kingston is being opened via Eel and Sydenham lakes, over which ore will be hauled to the market.

THE JOHNSON MINE.

Lomer, Rohr & Co. have commenced work recently on the old property known as the Johnson lot, in the sixth concession of Loughborough, with a force of 12 men and have taken out 40 or 50 tons of high grade phosphate. These properties and the Foxton are under the management of Mr. F. M. Gorman.

THE FLEMING COMPANY'S MINE.

The Mining Review of Ottawa, referring to the Fleming Phosphate Company's mine in the fourth range of Portland township, (October No., p. 195) says :

> It is expected 1,000 tons of high grade ore will be taken out during the winter ; it is said to be one of the most remarkable phosphate deposits in Canada.

EAGLE LAKE MINE.

Work had been suspended on this mine during the months of November and December owing to the dulness of the market. The work done during the year has been in the old openings of the mine. About 250 tons of No. 1 and 500 tons of No. 2 phosphate had been mined. An average staff (for about six months) of 15 men were employed. Part of the time, however, the men were employed at the saw mill. The old stock of lumber has been marketed.

Shaft No. 1 has now reached a depth of 175 feet ; the rock is more eruptive, but the same grade of ore is maintained. Considerable stoping has been done in the opening and the vein matter has increased in size.

A new shaft 50 feet in depth has been opened on the lead of phosphate, and the mine is in good condition for working. The iron deposits in connection with this mine have not been worked largely. About 800 tons of 65 to 70 per cent. magnetic iron ore is ready for shipment.

ST. GEORGE LAKE MINE.

This mine has been worked with 12 men for three months during the year and 220 tons of high grade phosphate shipped to London, England, with the first grade ore from the Eagle Lake mine. Work has been done chiefly in the easterly pit which has reached the depth of 60 feet. The ore is still raised with a whim.

SILVER LAKE MINE.

This mine has been worked with a force of 15 men for four months during the year. The work has been confined to surface openings, some of which have reached the depth of from 15 to 30 feet. Two hundred and fifty tons of 80 to 85 per cent. phosphate have been taken out. The siding of the Canadian Pacific Railway has not yet been completed.

FRONTENAC MINE.

Shaft No. 1 has been sunk an additional depth of 20 feet, making a total depth of 70 feet. The vein of ore which has been followed averages from one to two feet in width and 20 feet in length. The vein in the stope averages two feet in width. Ten tons of 85 per cent. have been taken out. Six men were employed a month and a half during the year. Mr. T. T. Hampton of Sharbot Lake has charge of the works.

GYPSUM OR PLASTER OF PARIS.

Gypsum as defined in the glossary of the Commissioners' Report is "Sulphate of lime, usually white and crystalline, granular. Selenite is the pure crystalline form, and splits into plates which are very transparent. It is very soft and is the mineral which constitutes the second degree of hardness, talc being the first" Gypsum occurs in beds on the Grand river in southern Ontario, and on the Moose river in the northerly part of the province, a distance of 500 miles north of Toronto. Plaster of Paris is a plaster made of gypsum by grinding and calcining it, so called from its manufacture near Paris in France. In Canada this term has been adopted for gypsum in any form.

THE EXCELSIOR MINE.

The Excelsior gypsum mine which I visited recently is on lot 2 on the Grand River road, Jones tract, three miles east of the village of Cayuga, county of Haldimand. The property consists of 65 acres and has been worked for the last 15 years and large quantities of gypsum removed. In September, 1890, it was purchased by the Adamant Manufacturing Company of Syracuse, New York. This company has offices at 71 Genesee street, East Syracuse, and 100 Esplanade street east, Toronto. The supply for use at the mill in Syracuse is obtained chiefly from the Nova Scotia and New Brunswick gypsum beds. The mill in Toronto is supplied from this mine.

The mine was worked from the beginning of the year until June with a force of 5 or 6 men and 1,300 tons of gypsum were taken out, most of which had been carried over the tramway to the mill a distance of a quarter of a mile. A drift has been run in from the level surface in a northerly direction at an incline of a foot in ten to the distance of 175 yards. At a distance of 150 yards from the place of entrance the gypsum was reached in a layer of 4 feet in thickness lying between shale above and limestone underneath. The drift has been extended to a total distance of 400 yards following the continued bed of plaster from the place where it was first reached. At the foot of the incline in this drift a level has been run in east 125 yards and the gypsum removed to the width of 100 yards, the open space being filled in with waste rock as the work progresses, an opening of about 8 feet for the tramway and convenience of work being left. In this drift an air shaft 4 by 4 feet has been opened to secure ventilation and provide a way for going in and out of this part of the mine. Also from the bottom of the incline another level has been run in southwest a distance of 100 yards, from which large quantities of gypsum had been taken out. In this level an air shaft was opened 4 by 4 feet; 125 yards from the bottom of the incline another short level of 10 yards has been opened. Near the extremity of the main drift a small air hole one foot square has been opened to the surface, which is 60 feet above the workings.

The plaster is taken out of the mine on a horse-car carrying about 2,500 pounds per load and conveyed by tramway to the company's mill. The mill was idle at the time of my visit.

Some parts of the interior of the mine require additional timbering. Mr. John A. Nelles, who has charge of the work, informed me this would be properly done before work was recommenced. He has had the direction of the work at the mine from the time it was first opened.

GLENNY MINE.

The gypsum quarry on lots 1, 2 and 3 in the township of Cayuga, in the county of Haldimand, is about one mile east of the Excelsior mine and has been worked for forty years past. The Grand River Plaster Co. purchased this property about ten years ago, and has constantly worked it since. It has offices at Cayuga and at 67 William street, New York. The paid up capital is $50,000. The company holds the mining right for 300 acres and the surface right for 15 acres. The working force for ten years last past has varied from 10 to 35, averaging 15 men annually. The yearly output of gypsum reaches 2,000 tons.

The workings at this mine consist of a drift in a northeasterly direction run in at the bottom of a small elevation of 20 feet, half a mile from Grand river and about 5 feet above its ordinary level. The drift is run in 400 yards in length and follows mineral the whole distance except for 30 yards from the entrance; the bed averages 4½ feet in thickness and is said to extend laterally over an area of 35 acres, of which 4 or 5 acres have been worked out. At a hundred yards from the mouth of the drift a level in a southerly direction is driven in to the distance of 30 yards. At a further distance of 200 yards from the mouth of the drift a second level is run in for fully 100 yards and was the principal place of work in the mine at the date of my visit. Two other extensive openings have also been made at a still further distance from the mouth of the drift. Two air shafts are opened which afford good ventilation to the mine.

The gypsum is mined and loaded into dump cars by contract for 70 cents per ton. It is then hauled out at the expense of the company by a pony mule employed for that purpose over a well laid track by means of which two or three car loads of 2.500 pounds each can be taken at a trip. The company furnishes the explosives and timber for the mine. The mill in connection with this mine is capable of grinding 15 tons of land plaster in ten hours and is run only in the daytime. It has been fitted up for manufacturing calcined gypsum, which is used largely for hard finish for walls. The pure white plaster is selected for this purpose.

The rock is treated as follows: It is first sorted, then passed through a Kelly crusher and falls into the disintegrator, and thence it is elevated to a hopper which feeds the buhr-stones for grinding. When ground it is again elevated into a bin and shoveled into the kettle for roasting. A batch of 35 or 40 barrels is treated in about three hours, being actively stirred with mullers during the time of roasting. After roasting it is again screened and put into sacks or barrels for the market.

This property is in good working condition, being under the control of Mr. Robert Glenny who owns the surface right and from whom the company purchased the mining right. He has had charge of the work for the last nine years.

THE MERRITT MINE.

Another gypsum mine known as the Merritt mine is situated on lot 3 of the Jones tract. The mineral right embraces 106 acres. The property belongs to the Grand River Co. and was opened 16 years ago by Mr. Glenny; 10,000 tons of plaster at least have been taken out of it. The company purchased it from Mr. Glenny about the time that it acquired the Glenny mine, but it has been lying idle for the last seven years. Mr Glenny informed me that the quarry yet contains a very large quantity of excellant white plaster.

THE TEASDALE MINE.

A gypsum mine is being opened on lot 1 on the Huffman tract, and is owned by Mr Thomas Teasdale. Work was begun about a year ago. About 100 tons of plaster have been taken from the mine. Two men were employed in the work. The gypsum lies only a few feet above the ordinary level of the waters of the Grand river and serious difficulty sometimes occurs in working the mine on account of the inflow of water from the river this difficulty is common to most of the mines situated on the banks of the Grand river

MOUNT HEALEY MINE.

One of the oldest plaster locations is situated at Mount Healey on the Grand river on what is known as the Cook block, and contains about 70 acres. W. Donaldson & Co own the property and have worked it for he last 20 years (except for the last two years during which time the property has been idle), taking out an average of 1,000 tons annually. Mr. Donaldson informed me that work would be resumed during the coming winter. An area of about 20 acres has been worked over. The layer of plaster in this mine averages three feet in thickness and is about 20 feet below the surface; the rock above being shale, and underneath limestone.

MARTINDALE'S MINE.

In November I visited the gypsum mine situated on lots 54 and 56 River range Oneida township county of Haldimand. The mining right embraces 330 acres. Mr Thomas Martindale is the owner of the property and has worked it continuously since 1866. The annual product until 1885 was 2,000 tons, and since it has been about 60 tons. Six men were employed until recently; about 500 tons of plaster were on hand i

November. The plaster is mined by contract and removed by horse tramway to the rock house in cars capable of carrying about 2,500 pounds each. The mill, which is capable of grinding 2,000 tons yearly, is situated on the opposite side of the river, in the village of York: it is run only part of the time. The plaster, which is ground for fertilizing uses only, is usually hauled to Deans and Cayuga stations, Canada Southern railway, and Caledonia on the Hamilton and Port Dover railway, for shipment.

The gypsum extends over an area of about 200 acres, about 20 of which have been worked; the layer averages four feet in thickness and is from 25 to 40 feet under the surface. The inside workings of the mine are very extensive, reaching a distance of three-quarters of a mile from the opening on the bank of the river.

Some parts of the works I found in excellent shape, while other parts were in an unsafe condition for the workmen and others who had occasion to enter the mine. I required some of the older workings to be fenced off to prevent persons from entering them, as the hanging rock roof was liable to fall away at any time. I also directed the manager, Mr. George Millward, to construct a couple of stone pillars to support the roof at the place of present working, and to sink a shaft from the surface at a place which I indicated for the purpose of ventilation and to provide a way of escape in case of an accident, whereby exit by the usual passage from the mine might be barred.

THE GARLAND MINE.

This mine is on lot 13 in the sixth concession of Oneida township, county of Haldimand, and comprises 29 acres: it is owned by L. H. Johnson of Caledonia. The property has been worked for about 20 years. and not less than 20,000 tons of gypsum have been obtained from it. It has been held by the present owner for nine years and about 800 tons of gypsum have been mined annually. A working force of from four to six men has been usually employed. A drift due south was started on a plain surface and run in on an incline of one foot in ten, and at a distance of 86 yards the plaster was reached, averaging four and a half feet in thickness. The vein is overlaid with a thin layer of argillaceous shale, above which is clay to the surface. Underneath the layer of plaster is a conglomerate of lime, gypsum and clay. The drift is continued in the same course a further distance of 36 yards, then turns an angle to the southwest and is continued 28 yards to its terminus. The present workings are at the end of the drift.

The ore is removed from the mine by means of a horse tramway; the car when loaded contains 2,500 pounds. From the mine it is hauled to a mill in Caledonia a distance of three miles and there is ground as a fertilizer. I gave directions to the foreman, Wm. Smith, to replace some of the old timbers used as supports with new, to construct a siding or man hole along the tram-way, and to open at or near the end of the drift a shaft for ventilation and egress from the mine in case of accident.

THE PARIS PLASTER MINE.

The Paris plaster mine has been purchased recently by the Alabastine Co, of Paris, of which Mr. B. Church of Grand Rapids, Michigan, is a principal shareholder. He is also the general manager of the Alabastine Co. of Michigan. Mr. J. W. Wheeler, who has the management of the company's works at Paris, accompanied me in a recent visit to the mine, which is situated one mile and a quarter east of the town of Paris, on the south side of the Grand river. The mining right comprises 140 acres, and has been constantly worked for the last seven months by a few men who mine the gypsum and deliver it at the mouth of the shaft by contract at $1 per ton. It is taken out of the mine on a small hand car. The company provides the timber for the mine. A drift, starting at the foot of the hill a few feet above the level of the waters of Grand river, has been run in 400 feet in a southwest direction, passing most of the distance through the old workings of the mine, done in former years, but radical changes are required to make it safe and convenient for working the mine. Along the front of the bank of the river the gypsum has been worked out for a considerable distance; further back under the hill, at a depth of 130 feet from the surface, where it is now being taken out, there is apparently a large body of mineral still. The bed is composed of gray interstratified with layers of pure soft white gypsum, and averages 5 feet in thickness. A slate roof a few feet only in thickness overlies the gypsum with clay and boulders above to the surface : and to render it secure and safe requires additional supports at the place of working. I gave instructions for this to be done. In places in the old workings the rock roof was left in a dangerous condition. The air was foul in the mine and at times the men were unable to continue work on this account. Another drift should be opened about 75 yards west of the present one and driven in to the present workings. It should be made sufficient in size and securely walled up so as to render it a convenient way for carrying on the work of the mine with safety and economy. The present drift should be abandoned for working purposes, but left open to secure proper ventilation in the mine.

I was informed by the manager that it was the intention of the company to renovate the workings. This being done the property will probably become a large producing one notwithstanding the removal already during thirty years of immense quantities of gypsum.

MICA.

The export of cut mica entered at the American Consulate at Kingston for the past year was of the value of $5,723. In addition to this a considerable trade was done in supplying the requirements of the home electrical and stove trades. White mica has been raised in the townships of Miller and Palmerston and county of Frontenac, and resumption of the industry is likely to happen. The importance of this mineral appears from the increasing demand for electrical purposes, along with the diminution of the supplies from the producing mines in the United States. The following figures are taken from the recent annual statistical review of the New York Engineering and Mining Journal of cut mica produced in and imported into the United States :

Year.	Imports.	Home production.	
		Quantity.	Value.
		lb.	
1881	$5,839	100,000	$250,000
1882	5,175	100,000	250,000
1883	9.884	114,000	285,000
1884	28,284	147,410	368,525
1889	97,351	49,500	50,000
1890	161,740	....	32,569
1891	132,744	....	....

The manufacture of ground mica, which is said to be profitable, has not yet arisen in this province, and it must be stated in this connection that a large trade in grinding low grade phosphates, actinolite, talc, ochres and mica apparently is waiting for development at Sydenham village in Loughborough, or at any one of the many points in the region referred to where cheap water power may be had.

THE SYDENHAM COMPANY'S WORKS.

The mica mine owned by the Sydenham Mining and Mica Co. near the lake at Sydenham has been lying idle throughout the year. The same company owns a property yielding pure white mica situated in the township of Effingham, in the county of Addington, respecting which Mr. Lacey says that "the output has been satisfactory and of high grade as to quality, and a ready sale has been found for it in the home market for stove purposes." A force of 12 men was employed for eight months during the year, but work has been suspended for the winter. The company's cutting works are in the village of Sydenham.

FOXTON'S MINE AND WORKS.

The mica cutting works of Mr. Fred. Foxton are in Sydenham, and he owns a mica property two miles west of the town, on lot 7 in the eighth concession of Loughborough. This property was not being worked at the date of my visit; it had been extensively worked during the former part of the year, and work will be resumed again with a force of 6 or 8 men in about ten days. A good return of amber mica had been obtained from this mine.

Mr. Foxton owns another mica property 16 miles north of Sydenham, in the township of Bedford, known as the Devil Lake mine, situated on the shore of a lake bearing the same name. The property had been worked with 18 men for the last six months in two shifts, day and night. They had been laid off for a couple of days at the time of my visit, but I was informed work would be resumed in about two weeks with the same force of workmen. This property has yielded a large quantity of colored mica.

WAKEFIELD MICA MINE.

A note appears in the August number of the Canadian Mining Review of Ottawa, as follows: "Mr. T. J. Waters has some forty men working day and night on his mica property recently purchased from Messrs. Skead & McVeity, and this mine is doing better than ever, producing about 30 tons rough per week. A cutting plant will shortly be put in." In the October number of the same publication mica properties are reported in the Kingston district: "Mica in large crystals, white and of tough, strong quality, has been obtained on lots 11, 12 and 13 of the southwest range on the colonization road in Abinger township and on lot 7 in the fifth concession of Effingham township."

BEDFORD MILLS MINE.

Pine & Co., of Boston, Mass., have leased an old phosphate property near the new Bedford mills on Blue lake, and were engaged in sorting over some of the old phosphate dumps and opening some new leads. A tunnel had been run into the hill for a distance of 150 feet, starting about 12 feet above high water mark on the lake; a good yield of phosphate had been obtained. About 20 rods from the opening of the tunnel, and on the summit of the elevation, a shaft had been sunk to the depth of 65 feet and a considerable quantity of amber mica had been taken out.

THE GODFREY MINE.

Mr. V. P. Day of Harrowsmith, on the Kingston and Pembroke railway, writes of recent date respecting the Godfrey mica mine: "This property is on lot 2 in the first concession of the township of Hinchinbrook, county of Frontenac, on the line of the Canadian Pacific railway, a quarter of a mile from the track and one mile from Godfrey station. The property is owned by Mr. C. H. Godfrey, but has been worked only six months during the year. Eight prospect pits have been opened, averaging 14 feet in depth. Of the output 60 tons of mica in the rough as selected at the mine have been sold from $120 to $200 per ton. There is still a large quantity of valuable material on hand. The quality is very superior light amber, very hard and flexible. As yet the leading vein has not been discovered. In all the pits opened mica has been found in paying quantities, and is on a second ledge supported by a heavy slide of gray spar extending fully a quarter of a mile. It is intended to prosecute the work vigorously next season."

THE FRONTENAC REGION.

Amber and brown mica are generally found with the phosphates of Loughborough, Storrington and Bedford in Frontenac. It may be here incidentally stated that a line drawn from Sydenham village in Loughborough to Sharbot Lake in Oso would be the axis of a mineral region in which have been found magnetic and hematite ores, galena, baryta, phosphate of lime, mica and graphite. The same region affords excellent sandstone, marble and soap-stone. The bands of crystalline schists in which mica is found are numerous, and but few have been developed. This region has been the only producer in Ontario for several years.

ASBESTOS.

The Engineering and Mining Journal of New York, giving the statistics for 1891, says (page 7): "Asbestos of inferior quality is found in a number of localities in the United States, but these have never become very important. The chief source of the fibrous asbestos suitable for weaving formerly was Italy, but since 1879 the Canadian mines near Thetford, province of Quebec, just north of Vermont, have become the chief source. The mineral occurs in veins with fibres perpendicular to the walls. Four grades are made. No. 1 has fibres one inch long and upwards, and sells now for $170 or more per ton; No. 2 has fibres under one inch but still good for weaving; No. 3 has bits of gangue mixed with the fibres; and No. 4 is the waste material good only for grinding. The American market is principally supplied with the Canadian asbestos."

The total production of asbestos for the Dominion of Canada for the year 1890 was 8,000 tons, valued at $1,039,661, equal to nearly $130 per ton.

On lot 13 in the ninth concession of Marmora, containing 100 acres, Mr. J. C. Boyne of Marmora has opened an asbestos mine by sinking several test pits of a few feet in depth over an area of two acres, from which a small quantity of excellent asbestos has been obtained. It is found on a hill ranging from 50 to 70 feet in height, and has been worked to only a limited extent. It is the intention of the owner to work the property with a strong force in the spring. The property is two miles from Rowan station on the Central Ontario railway, adjoining the public road.

THE METALLURGICAL INDUSTRY.

Without some development of the metallurgical industry the future of mining enterprise in this province will always fluctuate with the varying changes of opinion as to the value of mining investments, with the changes of tariffs, with the cost of transportation to manufacturing centres and with the competition of foreign mines. I communicated in my last report some opinions given me by persons interested in the mining industry as to the best means of developing the mineral resources of the province. An article on the subject of the metallurgic department of the Sheffield (Eng.) Technical School, in the Canadian Mining Review for November last, may be permitted insertion here.

To Prof. Arnold's laudable ambition of establishing a metallurgic workshop-school that should be an actual copy of the appliances and practical methods of the very best systems of steel manufacture and iron founding is due the creation of this institution, for which it is claimed that it will "enable a student to perfect himself in the actual art of manufacture and permit him, with a confidence born of actual experience, to take a prominent position amongst the supervising and controlling staff of a steel-manufacturing establishment." If in the very cradle of steel-manufacture an institution of this kind is necessary and meets with the approval of the highest technical authority, how much more should the necessity for a still more complete equipment for instruction in metallurgy impress itself on the people of this country, who have a wider range of mineral resources awaiting development, and the necessity before them of either educating their youth in metallurgical knowledge of the first order or of remaining ignorant and inept as a people in these industrial enterprises which withdraw year after year millions upon millions for metal manufactures within the scope of native resources, and more lamentable loss still—withdraw yearly a considerable portion of the industrious youth of the land.

Passing from the description of the engineering shops, physical laboratory and wood-working departments, the following is an outline of the equipment of the metallurgic department, given with plans in an extra edition of the London Ironmonger of the 10th ult:

The open-hearth steel furnace—of 25 cwt. capacity—with a complete gaseous fuel plant and hydraulic machinery; a 50-ton testing machine; a crucible steel house, with two melting holes, pot house and pot-making tools; a flame and ore-annealing furnace for malleable iron castings; an iron foundry equipped with belted cupola, drying stove and green sand castings. The laboratory is equipped with the most modern apparatus for rapid and accurate chemical examination of iron and steel, fuel and refractory materials. Apertures are provided at various parts of the furnace for testing temperature, for aspiring gases for analysis and for the spectroscopic examination of combustion and oxidation. By means of glycerine vacuum gauges the pressure and velocity of the gases in any part of the furnace can be ascertained. It is therefore possible to obtain a complete diagnosis of the furnace—both thermic, physical and chemical—at any stage of its operation. The hydraulic plant in connection with the furnace consists of a compressor, accumulator, ladle crane, centre crane and ingot breaker. The iron foundry has a cupola for melting half a ton of metal. The gaseous fuel generating plant is fitted for demonstrating the various different characters of useful combustible gases from solid and liquid hydrocarbons.

Amongst the donors to this institution are the dukes of Norfolk and Devonshire, Sir T. Mappin, the town trustees and Thomas Jessop, for a total of £8,000. Some ancient guilds and trading companies have assumed a yearly liability of £1,750 for five years, and Sir T. Mappin has given £1,000 towards a prize fund. The endowment fund is not fully quoted, but it is altogether likely that the above statement comprises the principal part of the equipment and sustentation fund.

An institution sufficiently comprehensive to take in the whole field of metallurgic operations, designed "to be an actual copy of the appliances and practical *modus operandi* of the best systems of iron and steel manufacture," with the addition of the Bessemer process, and also with a plant for the reduction of gold, silver, copper, nickel and lead ores, and for refining these metals, "such as to enable a student to perfect himself in the art of manufacture and to permit him with a confidence born of actual experience to take a prominent position amongst the supervising and controlling staff of a steel manufacturing or indeed any metallurgical establishment," was submitted in outline to the consideration of the Ontario Government last year in Inspector Slaght's report. Time will conclusively show that no other system for placing the foundation of mining as well as metallurgical enterprise on a sure basis can compare with this. But time is in this country the element which costs, although there is an oriental wealth of it everywhere. So many others get ahead. Even Russia in the midst of her hunger-stricken peasants, is devising well-laid plans for great iron manufactures which command the attention of western Europe, and will no doubt draw to her large sums for investment. Illustrations just like this will continue as the years go by until our forests become huckleberry jungles and our mines the property of foreign enterprise, reaping wealth in fields of industrial activity which we seem unwilling to learn how to occupy. All this will come to pass unless our Governments, Federal and Provincial, will wake up.

TRANSMISSION OF POWER.

The extensive application of electricity for the transmission of power from waterfalls to mining sites for running mining machinery may call for legislation to enable parties to run their wires over the property of neighboring owners. The erection of systems of wire rope transmission for carrying ores from mines to railways and navigable streams may also require to be facilitated by extending to them the operation of the Act which enables mining concerns to construct tramways and expropriate property therefor.

A. SLAGHT, Inspector.

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SECOND REPORT OF

THE BUREAU OF MINES

1892

PRINTED BY ORDER OF THE
LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO:
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To His Honor George Airey Kirkpatrick,
Lieutenant-Governor of Ontario :

I have the honor to transmit herewith, for presentation to the Legislative Assembly, the Second Report of the Bureau of Mines.

I have the honor to be, Sir,
Your obedient servant,

A. S. HARDY,
Commissioner of Crown Lands.

Department of Crown Lands,
Toronto, 15th May, 1893.

SECOND REPORT OF

THE BUREAU OF MINES.

To the Honorable Arthur S. Hardy,
Commissioner of Crown Lands:

Sir,—I am submitting herewith, for presentation to His Honor the Lieutenant-Governor, the Second Report of the Bureau of Mines.

Statistics are given of the areas of mineral lands sold and leased during the calendar year 1892, as well as of the mineral production of the Province for the year ending 31st October. Returns of the latter are made to the Bureau under the provisions of the 60th section of The Mines Act 1892.

Revival of interest in the iron industry suggested the importance of reviewing our past experience with blast furnaces in Ontario, and also of collecting information on the iron ore resources of the Province. Accordingly some space is devoted to these subjects. All statements have been carefully verified, and have been drawn chiefly from official documents and scientific reports and papers.

Separate chapters are also devoted to nickel and its uses, the peat industry, the mining laws of the Province and other subjects, including a very interesting paper by Prof. Coleman on our exhibit of minerals at the World's Fair.

Under the 67th section of The Mines Act 1892 the Inspector of Mines is required to make an annual report of his proceedings to the Director of the Bureau, [illegible] his Report accompanies this Report of the Bureau.

I have again to acknowledge the valuable services of Mr. Thomas W. Gibson [illegible] the conduct of the affairs of the Bureau. He is a faithful, exact and capable officer.

I have the honor to be, Sir,
Your obedient servant,

ARCHIBALD BLUE,
Director.

Office of the
Bureau of Mines,
Toronto, May 15, 1893.

REPORT OF

THE BUREAU OF MINES.

I.

STATISTICS.

Statistics of mineral production and grants of mineral lands.

The sixtieth section of The Mines Act 1892 requires the owner or agent of every mine to which the Act applies to send to the Bureau of Mines on or before the first of December of each year the statistics of his mine for the year ending on the preceding 31st day of October, according to a form prepared and furnished for this purpose by the Director of the Bureau. The information which the Act requires to be given in this way covers the number of persons employed at the mine above and below ground respectively, the number of such persons over seventeen years of age, the number between fifteen and seventeen years, the average rate of wages earned by workers in each class, and the total amount of wages paid during the year, together with the quantity in statute weight of the mineral dressed and undressed which has been sold, treated or used during the year, and the value or estimated value of it. The Act makes every owner or agent of a mine who fails to comply with this provision of it, or who makes any return which is to his knowledge false in any particular, guilty of an offence for which he is liable to a penalty of [illegible] dollars, and to a further penalty of five dollars for every day the offence continues after written notice of it has been given. The returns received have not been altogether satisfactory, but doubtless they will improve when the requirements of the Act are better understood and the value of statistics come [illegible] be better appreciated by mining men. The statistics of the sale and leases of mining lands have of course been prepared from the records of the Department of Crown Lands. In respect of number of grants for which patents and leases have been issued, as well as of areas conveyed, it will be observed that the districts of Algoma and Nipissing continue to keep the lead. These are the best known mineral regions of the Province, and the most valuable minerals are found within their limits, including gold, silver, nickel and copper. Until recently gold was supposed to be found in workable quantities only in Hastings and in the region in and around Lake-of-the-Woods. But within the last two years promising leads have been discovered in the valleys of the Thessalon and Vermilion rivers in Algoma, and in the vicinity of lake Wahnapitae in Nipissing, and prospecting has been active in those regions, with the result that quite a number of locations have been taken up. Important discoveries of silver, copper and antimony ores have also been reported in the township of Barrie in Frontenac, and of steatite in Grimsthorpe in Hastings, and in both townships prospectors were busily employed last year.

SALE AND LEASE OF MINING LANDS.

Mineral lands sold

Under the new Act mining lands may be acquired by purchase of the fee simple, or by lease for a term of years with right of renewal. The following table shows by districts the areas for which mining patents were issued in 1892, and the amounts paid therefor into the treasury of the Province:

District.	No. of Patents.	Acres.	$
Rainy River....................	27	1,144	3,109.00
Thunder Bay..................	12	2,391	5,598.00
Algoma........................	12	1,500	4,214.50
Nipissing......................	10	779	1,706.50
Elsewhere..........................	4	386	645.00
Totals......................	65	6,200	15,273.00

No fair comparison can be made with the sales of the previous year, for the reason that in 1891 a large number of patents were issued for which application had been made under the provisions of the old Act. Besides, the preference is now for taking land under the leasing system.

and leased.

The next table shows the number of mining leases issued during the year, the acreage which they covered, and the amount paid into the treasury for the first year's rent charge:

District.	No. of Leases.	Acres.	$
Rainy River....................	9	1,517	1.517.00
Thunder Bay..................	6	990	990.00
Algoma........................	32	4,842⅛	4,842.51
Nipissing......................	34	3,747⅜	3,749.25
Elsewhere.....................	14	2,026	1,215.60
Totals......................	95	13,122⅓	12,314 36

Popularity of the leasing system.

The leasing clause went into operation on 4th May, 1891. The number of leases issued in that year was 47, embracing an area of 4,998 acres, and the first year's rental paid was $4,886. The average area of locations was [illegible]00 acres, while in 1892 it rose to 138 acres, and the number of leases issued was doubled.

A reason for the larger number of leases granted in the latter year is found in the fact that a third of the previous year had passed before the system was brought into effect; yet this is to be said, that little or no prospecting for minerals in our northern districts can be undertaken before the first of May.

As evidence of the continued growing favor of the system with miners and prospectors, it may be stated that the number of mining leases issued to May 6th of the current year is 54, covering an area of 6,656 acres. The number of patents issued to the same date is 30, covering 2,912 acres. It is probable therefore that the transactions of this year will considerably exceed those of last year.

Payments of the second year's rental fell due last year upon 27 locations, covering 2,461½ acres, to the amount of $603. The rent charge for the second and all subsequent years of the term of a lease is only one-fourth of the rate for the first year.

MINERAL STATISTICS.

Building Stone.

About one hundred quarries were worked during the year for building stone material, chiefly limestone and sandstone. It was not possible to procure returns from all of them, but a careful estimate gives the following statistics of quantity and value for the different classes of material:

Dimension Stone	cu. ft.	2,600,000	$680,000
Heads and Sills	cu. ft.	50,000	26,000
Coursing Stone	sq. yd.	64,000	42,000
Rubble, etc	cu. yd.	730,000	132,000

Making a total value of $880,000. The amount of wages paid to workmen was $730,000.

Natural Rock and Portland Cements.

Much the greater portion of the cement made in Ontario is the product of natural rock, but although the quantity was 7,977 barrels more than in the preceding year the value was $839 less. Portland cement began to be made in 1891, when the output was 2,033 barrels, valued at $5,082. The quantity and value of both classes produced last year are given in the following table:

Natural Rock	bbl.	54,155	$38,580
Portland	"	20,247	47,417

Making a total of 74,402 barrels, valued at $85,997. The amount paid for wages was $53,151.

Lime

The returns received of the quantity of lime burnt last year are not complete. but an estimate places it at 2,600,000 bushels, valued at $350,000, with amount for wages of $120,000.

Brick, Roofing Tile and Terra-cotta.

The following table gives the quantity and value of drain tile, common and pressed brick, roofing tile and terra-cotta made in the Province last year —drain tile and common brick being an estimate based on 161 returns:

Drain Tile	No.	10,000,000	$100,000
Common Brick		175,000,000	980,000
Pressed Brick, plain		20,342,000	198,350
Pressed Brick, fancy		1,328,000	32,253
Roofing Tile		383,000	8,613
Terra-cotta			20,119

The pressed brick works have added largely to the output of 1891, the increase in the number of pieces being 8,431,000, and in value $102,636. One new establishment was put into operation during the year, that of the Thomas Nightingale Pressed Brick Co. at Port Credit. The brick at these works is made from the red shale of the Medina formation. The amount paid for wages during the year by the pressed brick companies was $88,865. The amount of wages paid for making common brick and drain tile was $445,000.

Pottery.

The value of pottery made during the year was $80,000, and the amount of wages paid to workmen in the business was $25,000.

Gypsum.

The gypsum mining industry has been quiet during the year and production was only 72 per cent. of the previous year's. There has been however a considerable increase in the manufacture of alabastine and plastico. Following are the figures for the year:

Gypsum	tons	3,870	$14,100
Alabastine and plastico	"	108	11,800

The amount paid for wages was $10,465.

Phosphate of Lime.

The depression in the phosphate business still continues as a consequence of the low price at which Florida phosphate is sold in the European markets. Only three of the Ontario mines were worked last year, and these to much less than their full capacity. The total quantity raised was 2,381 tons, valued at $23,810. The amount paid for wages, including some development work on other mines, was $9,400.

Salt.

The total quantity of salt of all kinds made during the year ending October 31, as reported to the Bureau by Mr. John Ransford, secretary of the Association, was 43,387 tons, valued at $162,700. It has not been possible to get information in detail, but the following figures are compiled from returns made by the owners of six salt works :

Coarse salt	tons	2,550	$ 9,005
Fine salt	"	8,221	35,461

The cost of wages for this quantity of coarse and fine salts was $9,885. Computed at the same rate the cost of wages for the total make of the year would be about $37,800.

The salt-producing territory of the Province was proven last year to extend as far south as Windsor. A well drilled at the Canadian Pacific Railway station struck a bed of salt 30 feet in thickness at a depth of 1,138 feet. In the township of Orford, in Kent county, a deep well drilled in 1890 for natural gas by Mr. Hiram Walker, of Walkerville, went through a bed of clear white salt 171 feet in thickness, reaching it at a depth of 1,510 ft.

The salt beds of the Province are proven by borings and producing wells to extend under the whole of the counties of Huron, Lambton, Kent and Essex, as well as portions of Middlesex and Bruce, and to cover an area of about 4,000 square miles. Near the borders of the formation the salt thins out to one bed, but in Huron there are usually to be found three distinct beds, separated by shale, whose aggregate thickness is about 90 feet. The greatest known thickness of a deposit is in the southern limit of the field where, as shown by the record of Mr. Walker's boring in Orford, there is one bed 171 feet in thickness.

Mica.

Only one of the mica mines was worked last year and it produced but seven tons, valued at $1,500. The amount of wages paid for labor was $150.

Nickel, Copper and Cobalt.

Four companies carried on mining and smelting operations in the Sudbury district last year. The quantity of ore raised was 72,349 tons, [illegible] the quantity smelted was 61,924 tons. Three of the companies have erected bessemerizing plants in connection with their works, employed to enrich the matte ; but only a portion of the matte is treated by this process. The quantity of ordinary matte produced at all the furnaces was 6,278 tons, and of bessemerized matte 1,880 tons. The following table gives the estimated metal contents of these mattes and their values at the works:

Nickel	tons	2,082	$590,[illegible]02
Copper	"	1,936	232,125
Cobalt	"	8½	3,713

The total value of the metal contents therefore was $826,750, the nickel being calculated at $284 per ton or 14.2 cents per pound, the copper at $120 per ton or 6 cents per pound, and the cobalt at $437 per ton or 21.84 cents per pound.[1] All the ores yielded nickel, the average being 3.36 per cent;

---

[1] The quantities here given are the estimated contents of the respective refined metals in the mattes, but values are computed on the selling price of mattes at the works and not on the price of the metals after they have been refined in Great Britain, the United States or elsewhere. London quotations for nickel ruled steadily at 42 cents per pound, and New York quotations at 48 to 52 cents, during the latter half of the year,—the higher price in the United States being maintained by the protection of the customs duty. But it would be very misleading to make the value of nickel contents in the matte at Sudbury the same as the value of refined nickel in New York or London.

the ores of three companies yielded copper, the average being 3.19 per cent.; and the ores of one company yielded cobalt, but the average was only .1007 per cent.

Employment of labor.

At the mines there was employed underground an average of 197 men and above ground of 243 men over seventeen years of age, while of boys under seventeen years of age there was employed an average of only 10, all above ground. The average number of men employed at roasting and smelting was 240,—the average of all classes of workers being 690. The mines of one of the companies were worked 310 days, of another 261, of a third 173, and of the fourth 155. The smelting works of one company were in blast 337 days, of a second 290, of a third 67, and of the fourth 32. The aggregate of time of labor in the mines may therefore be computed at 105,890 days, and at roasting and smelting 52,428 days, making a grand total working time of 158,318 days for the 690 employés. The amount of wages paid for labor by the four companies was $339,821, and the average wage per day would therefore be $2.14⅔.

Gold.

Gold mining has been comparatively active during the year, but the work carried on has been mostly of development character. Locations have been worked in the county of Hastings, in the district of East Algoma and in the region of Lake-of-the-Woods. Nine companies have made returns of work done during the year ending 31st October, which show that 3,710 tons of gold ore was mined, the value of which is estimated at $36,900. The number of men employed above ground by those companies was 85, and the number underground 40. The aggregate working time of the men was 12,932 days, and the amount of wages paid was $22,750. The average wage per day would therefore be $1.76.

Mills for treating the ore were being erected at a number of mines, several of which are now in operation. New processes of treating ore are being adopted, and interesting results are looked for this year.

Operations on Lake-of-the Woods.

In the month of December eight properties were in course of active development on Lake-of-the-Woods, the number of mines and laborers employed upon them being 159. Since then reduction mills put up at two of the mines have, it is reported, been treating the ores very successfully. According to accounts published in the Rat Portage newspapers, gold bricks of the value of $1,000 are produced by each plant weekly.

Ophir mine.

The Ophir mine, north of Thessalon, was purchased last year by a Duluth syndicate for $100,000. Several shafts have been sunk on the vein and the show of gold has aroused lively expectations. Treating works are being erected at the Ophir, and it is expected that they will be started in the month of August.

Creighton mine.

The Creighton Gold Mining Co. is developing a location of much promise in the township of Creighton, west of Sudbury. Sixty-three men were employed on the works in February, at which time a shaft of 8 by 9 feet was sunk upon the vein to the depth of 110 feet. Steam drills and hoists were in operation at that time, but air compressors, crushers and other machinery had been ordered and suitable buildings were in course of erection.

Operations in Hastings.

Three mines are being worked in the county of Hastings, one of which has reached a depth of 140 feet. The pyritic ore at this latter mine is being treated in a Crawford mill, and the yield of gold is stated to be very satisfactory. At one of the other mines a new process of treating mispickel ore is going to be tried, which is claimed to give good results in the laboratory.

Silver. Nearly all the silver mines in the Lake Superior district have been idle during the past year, and the work done on five or six locations had for its chief object the opening and proving of veins. This is one of the results of the depreciation of silver. An accompanying result is the activity noticed in gold mining, which is also a feature of the industry in the United States and elsewhere.

At one of the mines six men were employed under ground and one above ground for 306 days, and the amount of wages paid for labor was $3,942, or at the rate of $1.84 per day. Ten tons of ore was taken from this mine, the value of which is put down at $732.

Petroleum. The quantity of crude petroleum produced in the Petrolea and Oil Springs fields was 800,000 barrels (28,000,000 imperial gallons), valued at $1,000,000. This is 94,647 barrels less than for the preceding year.

Full details of the industry have not been obtained, as only five refineries have made returns to the Bureau. These refineries treated 11,929,446 gallons in the year, being 42.6 per cent. of the whole yield, the product of which is given in the following table:

Illuminating oil	imp. gal.	4,627,593	$391,628
Lubricating oil	"	1,472,924	58,918
All other oils	"	3,260,912	116,118
Paraffin wax	lb.	276,027	29,922

The amount of wages paid for labor at those five refineries was $40.517. On the same basis, the refined product of the total crude yield of the year would be—

Illuminating oil	imp. gal.,	10,862,894	$919,315
Lubricating oil	"	3,457,570	138,304
All other oils	"	7,654,723	272,577
Paraffin wax	lb.	647,950	70,239

This would give a total value of distilled products of $1,400,435, and at the same rate the amount of wages paid for labor would be $95,110. This does not of course include wages paid to workmen employed in the production and storage of crude petroleum. The total number of employés maintained by the industry is estimated to be about 1,500, and the amount of wages paid for labor of all kinds about $650,000.

Natural Gas. In the Welland gas field forty-nine wells were bored last year, of which thirty-six are gas producers. The total number of producing wells in the district is sixty-five. In Essex two new producing wells were bored last year, and there are now eight in that district. There are about one hundred and fifty miles of pipe laid for the delivery and distribution of gas in both districts, and the value of gas sold to consumers last year was about $160,000. The total amount of wages paid for labor was $55,000, a large proportion of which was for drilling new wells. The returns received from gas companies have not been very satisfactory, especially those made by companies delivering to consumers in Buffalo.

Iron. No iron mining is reported for the year, but several properties were prospected with a view of proving the quantity and value of their ores.

SUMMARY OF MINERAL PRODUCTION.

Quantity and value of mineral production, and amount of wages paid for labor, in 1892.

Product.	Quantity.	Value. $	Wages. $
Dimension stone....cu. ft.	2,600,000	680,000	730,000
Heads and sills .... " "	50,000	26,000	
Coursing stone ....sq. yd.	64,000	42,000	
Rubble, etc ....cu. yd.	730,000	132,000	
Natural Rock Cement..bbl	54,155	38,580	53,151
Portland Cement ..... "	20,247	47,417	
Lime ... .bu.	2,600,000	350,000	120,000
Drain Tile............ no.	10,000,000	100,000	445,000
Common brick......... "	175,000,000	980,000	
Pressed brick, plain ... "	20,342,000	198,350	88,865
Pressed brick, fancy... "	1,323,000	32,253	
Roofing tile .... "	383,000	8,613	
Terra-cotta .... "		20,119	
Pottery .... "		80,000	25,000
Gypsum..............tons	3,870	14,100	10,465
Alabastine and plastico "	108	11,880	
Phosphate of lime ..... "	2,381	23,810	9,400
Salt.................. "	43,387	162,700	37,800
Mica .... "	7	1,500	150
Nickel .... "	2,082	590,902	339,821
Copper .... "	1,936	232,135	
Cobalt .... "	8½	3,713	
Gold ore .... "	3,710	36,900	22,750
Silver ore .... "	10	732	3,942
Petroleum ..... imp. gal.	28,000,000		650,000
Illuminating oil " "	10,862,894	919,315	
Lubricating oil " "	3,457,570	138,304	
All other oils .. " "	7,654,723	272,577	
Paraffin wax ....lb.	647,950	70,239	
Natural gas	....	160,000	55,000
Totals	....	5,374,139	2,591,344

The total value exceeds the production of last year by $668,466; but the principal increase is in nickel and copper, in which there is a different basis of values for the two years. The table, it may be explained, gives no

No statistical account of exploratory work.

account of properties upon which exploratory or development work was done during the year. Of these there are a considerable number, especially in the gold and nickel fields. In some cases numerous test pits and shafts have been sunk and several hundred tons of ore raised; a work which, though not included in statistical returns of quantity, value or wages, may come to have an important effect on the future of mining operations in the Province.

Correspondence.

As was stated in the Report of last year, all transactions relating to sales and leases of mining lands in the surveyed territory of the Province has been assigned to the Bureau of Mines, which of course includes all correspondence in respect of such transactions. The number of letters written by the Bureau last year, including this branch of its work, was 1,417; but there was sent out in addition 125 notices to lessees of mining lands *re* rentals, and over 1,000 circulars and schedules for the collection of mineral statistics.

II.

IRON-MAKING IN ONTARIO.

A commonwealth without a blast furnace.

For a country which has had self-government a hundred years, which has a population of more than two millions and a school system of unsurpassed excellence to provide for their education, which possesses rich resources of soil, timber and minerals, including iron ores, which sustains varied industries, and which has large amounts of capital invested and seeking investment, much of it employed in the neighboring States,[1] the Province of Ontario is singular in being almost alone among the great commonwealths of our continent without a blast furnace for the production of metallic iron.

Iron-making has been undertaken at different times and at various places in the Province, but in almost every instance by men without skill or experience, and with only very limited means.

Blast Furnace at Gananoque Falls.

Iron making in Leeds county.

The first blast furnace in Ontario was built by a company in the county of Leeds about the year 1800, at the falls of the Gananoque river. It was an old-fashioned stack, and in connection with it was a forge for the manufacture of bar iron. But the location was too far from ore deposits, having regard to the difficulties and cost of transportation at that early period in the history of the country, and as the ore used was of inferior quality and had to be drawn a considerable distance the venture was abandoned after a trial of two years.[2]

Blast Furnaces in Norfolk County.

Iron making in Charlotteville and Houghton, in Norfolk county.

The next furnace was started about twenty years later, in the township of Charlotteville, county of Norfolk, to smelt the bog iron ore in that district, and it was carried on successfully for a quarter of a century, or until the supply of ore in the locality became exhausted. The smelting of iron appears to have commenced early in 1823, as under date of 15th January in that year the proprietors, Messrs. Joseph VanNorman, Hiram Capron and George Tillson, petitioned the Lieutenant-Governor in Council for leave to take and use ores in the locality, the property of which was in the Crown.

"The petition of the undersigned owners in the concern of VanNorman and Company, being the proprietors of the iron works established on lot No. 16 in front of the first concession of Charlotteville, in the district of London, most humbly sheweth: That your petitioners have their said iron works now at this time heating for the purpose of going immediately into operation:[3]

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[1] The bank statement in the Canada Gazette for the month ending February 8, 1893, showed that there was due to Canadian banks from their own agencies and other banks in foreign countries at that date $21,397,371, while there was due to the latter from the former only $87,710. The balance, $21,309,661, represents the amount of our cash or capital abroad, all or nearly all of which is used for commercial purposes in the United States, but which may be called in whenever it is wanted. At the same date there was due from British banks $1,159,930, and due to them $4,766,619.

[2] Hiel Sliter's Recollections in Leavitt's History of Leeds and Grenville, p. 62.

[3] In a paper furnished by the late Mr. VanNorman, about eight years ago, it is stated that the furnace had been completed and put in blast in 1822, but the statement in the petition is no doubt more authentic. The work of constructing the furnace was begun by John Mason, in 1815, but the inner wall collapsed when only a few tons had been smelted. Mr. Mason died soon after, and the property was acquired by Mr. VanNorman.

That your petitioners trust their said iron works are upon such a scale that they will be found fully efficient for all the purposes required, and therefore pray that your Excellency will be pleased to grant them the privilege of taking and using, from time to time, for and at their said works, such iron ore as may be required from any place or places where the same may abound within the townships of Charlotteville and Middleton."

Iron ores reserved to the Crown.

The patents issued in Upper Canada down to the end of 1823 reserved iron ores to the Crown, except in rare instances; but the petition of the company was no doubt intended to cover the acquisition of ores found upon all lands in the townships named, whether the title to such lands had passed to settlers or was still in the Crown. The report to Council however assumed that the petition only referred to ores on patented lands, and instead of conceding to the company the privilege to take and use them, it was recommended that this privilege should be accorded to the owners of the land.

"It is respectfully submitted that the proprietors of land in Charlotteville and Middleton may be discharged from the restraint in their respective patents as to digging and disposing of iron ore, should it be the opinion of his Majesty's law officers that it may be, and if otherwise that his Majesty's Government may be moved to authorize such discharge."[4]

A second furnace for treating bog ores in the county of Norfolk was built by Mr. VanNorman in the township of Houghton in 1854, with the object of supplying the Great Western Railway with pig iron for the manufacture of car wheels, but the iron proved to be unsuitable and the furnace was blown out.[5]

THE MARMORA IRON WORKS.

Iron making in Hastings county.

In 1820 Charles Hayes began to take steps for making iron at Marmora, in the county of Hastings, and a furnace which was erected there to smelt hard magnetic ores had the ill-fortune to ruin or cripple three or four successive owners in the course of forty years, although for the greater part of that time it was out of blast. Little is known of the early history of this enterprise, but the Departmental and Executive records show that it received some measure of encouragement at the hands of the Government and the Legislature. The first reference to it appears under date of October 26, 1820, when the following Order in Council was adopted:

Land grants by the Government for site of works and fuel reserve.

"Mr. Charles Hayes being heard on a proposition to establish iron works at the Crow river in the township of Marmora, in the Midland district, his Excellency with advice of Council was pleased to grant permission to him to open a road from the Crow lake to Louis Rosebush's in Sydney, as nearly on a straight course as the reserve for roads in the respective townships will admit, and to erect works near to the said lake on Crow river, promising to confirm a location of twelve hundred acres comprehending the site of the works and the buildings inhabited by the labourers by grant of the land so soon as the Executive Government shall be satisfied that works are so complete as to manufacture bar iron and hollow ware; and his Excellency with he advice aforesaid promises to reserve other twelve hundred acres in the neighborhood to supply fuel for the works, and that the grant of land be without the Crown fee, paying only the fee to the patent officers. It is further ordered that he be preferred for one year in the lease of such Crown or Clergy reserves as may be found within this grant and the reserve for fuel.[6]

The tract reserved under the last clause of the Order included the whole of the first and second and part of the third concessions of the township, subsequently changed to the half of the first, second, third and fourth concessions, and covered with Marmora lake an area of 12,000 acres.[7]

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[4] Orders in Council Book No. 6, p. 24.

[5] See Report of Commission on the Mineral Resources of Ontario, pp. 319-20 and 326.

[6] Orders in Council Book No. 5, p. 190.

On 1st October, 1821, Mr. Hayes applied for an extension of time as preferred lessee of this block, stating that he was then deeply engaged in the erection of his works and had "a vast number of men employed."[8]

On 7th June, 1823, he memorialised the Government for issue of the patents for the grant of 1,200 acres located as a site of the works, "having fulfilled the conditions of the Order in Council of 26th October, 1820;" and as the patents were issued in August following it is to be inferred that the furnace as well as the works for the manufacture of bar iron and hollow ware were then completed.[9]

In the same memorial Mr. Hayes petitioned for an enlargement of the fuel reserve from 1,200 to 1,800 acres, and that by act or instrument the grant thereof should be confirmed to him in perpetuity, which request the Council disposed of by the following Order:

"That six hundred acres of land adjacent to the reserve for fuel, for the iron works in Marmora, be added to that reserve, and the whole tract so reserved remain to the use of the iron works so long as they are improved as such without interruption of more than three years."[10]

Subsequently Mr. Hayes obtained permission to dig for and use ore of any description excepting gold and silver on any Crown or Clergy land leased by him.[11]

New reserve of lands for iron ores.

With respect to the reserved tract of 12,000 acres in Marmora, Mr. Hayes discovered that the deposit of ore upon which he relied was outside of its limits, and he submitted to the Government an offer to make a survey of three adjoining townships in which iron ore was likely to be found and to accept a percentage of the lands as his compensation for the work. Accordingly on 30th October, 1821, the following Order in Council was adopted:

"Upon the representation of Mr. Charles Hayes that the bed of ore on which he relied for supply of his contract with his Majesty's Government for iron ballast is discovered to be out of the limits of the reservations made for such purpose, and is likely to be found in the townships of Mora, Ninia or Carlos,[12] and that to obviate any risk of such ore falling into the hands of strangers by the draughts of the surveyors employed to survey the same, and proposing to undertake the survey of these townships at the low rate of four per cent. on condition of being permitted to locate such percentage in a manner to cover the iron ore: his Excellency the Lieutenant-Governor with the advice of the Council is pleased to order and direct that the Surveyor-General do contract with Mr. Hayes on the terms proposed for the survey of the said townships.[13]

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[7] Orders in Council Book No. 5, p. 251, 9th March, 1821. The reserve block is shown on the original map of the township by a shaded border.

[8] Writing to the Governor's secretary on 26th February, 1821, Mr. H. said: "Having had a survey made from the 13th lot in the first concession of Rawdon in a straight line to the rear thereof, and thence to the Crow lake in the township of Marmora, I have now had a road cut throughout which I imagine will be 15 miles in length."

[9] J. H. Bartlett of Montreal states that the iron works were first commenced at Marmora by Mr. Hayes in 1830. "The Manufacture, Consumption and Production of Iron, Steel and Coal in the Dominion of Canada," p. 29. Also Transactions of the American Institute of Mining Engineers, vol xiv, p. 527, by the same writer. But the property had passed into the hands of Hon. Peter McGill before that year as principal creditor of Mr. Hayes, and in 1828 he petitioned the Legislature for a loan of £10,000 to enable him to carry on the works.

[10] Orders in Council Book No. 6, p. 46. An absolute grant of the property was made by the Crown in 1853, upon payment of 10 cents per acre. [11] Ib. p. 47.

[12] Now known respectively as Belmont, Lake and Methuen. Among other curious names of townships in those days in that part of the Province were Alma, Emir, Zeta, Aye, Yea, No, Et, Jus and Norma. O. C. Book No. 5, p. 357.

[13] Orders in Council Book No. 5, p. 358.

Located in Belmont.

Business difficulties.

Marmora Foundery Co. incorporated.

In the summer of 1823 the surveys were well nigh completed, and Mr. Hayes solicited the Government for permission to locate in the township of Belmont the whole of his percentage for the three townships. The grounds of this request were, (1) "that the great body of iron ore on which your memorialist relies is within the township of Belmont," and (2) "that in the said township of Belmont is a lake to which from your memorialist's works is a line of water communication, and from which said lake your memorialist has it in contemplation to cut at some future period a canal to connect it with the river Trent, which would be of great importance in transporting iron and other commodities from the said works to the Rice lake, and *vice versa*, and would also be very beneficial to the public."[14] The patents were issued in July, 1824, and covered areas of 8,534 acres in Belmont, including lot 8 in the first concession, upon which is the Big Ore bed or Blairton mine. From this mine most of the ore smelted at the Marmora furnaces was taken. But Mr. Hayes appears to have already become involved in business difficulties, for in September of the same year he made an assignment in trust of a portion of his property, including the land upon which the works were built, to Peter McGill, Anthony Manahan and Robert Hayes. In February, 1825, Messrs. McGill and Manahan surrendered their trust to Charles and Robert Hayes, and in June the property was sold in part to Mr. McGill, who carried on the works for some time in this and the following year. In 1828 Mr. McGill sought, but unsuccessfully, to enlist the aid of the Legislature, having applied for a loan of £10,000, and in October, 1830, he sold the property to Mr. Hetherington. An Act to incorporate the Marmora Foundery Company was procured from the Legislature in the session of 1831, upon the petition of Messrs. Hetherington, McGill and Manahan, with an authorized capital of £50,000, the object as set forth in the preamble being to acquire the Marmora iron works, at that time the property of Mr. Hetherington, to the end that "the said iron works and manufactory should be conducted on an extensive scale, so that his Majesty's subjects in this Province may have a cheap and accessible market for a supply of iron wares independent of any foreign country." A further object as set forth was that "the said Company will be capable of furnishing such ordnance, military and naval stores in the line of their trade as his Majesty's Government may require in this Province in peace or war."[15] This corporation continued to exist at least in name until 1853, when the charter was amended under a new set of directors; but the records of the county registry office show that in 1834 Mr. Hetherington reconveyed the property to Mr. McGill.

Report on a scheme to utilize penitentiary labor in iron making.

The report of the Commissioners appointed in 1837 to ascertain upon what terms the lands and works of the "Marmora Iron Works" might be acquired by the Government, for the purpose of employing the convicts of the penitentiary in the production and manufacture of iron at Marmora, showed that the quantity of land held in fee in the two townships was 10,935 acres, besides the 1,800 acres of fuel reserve.[16] It also appears by this report that the works consisted of two furnaces for smelting ore, a casting house common to both, a forge for the manufacture of bar iron, four coal houses with a capacity of 35,000 bushels each, saw and grist mills, blacksmith's shop, carpenter's shop, store, dwellings, etc., "forming in the view of the Commissioners a more complete and substantial establishment than on its scale of magnitude can be met with in all North America." The value placed by

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[14] Memorial to his Excellency Sir Peregrine Maitland, 14th June, 1823.

[15] An Act to incorporate certain persons under the style and title of the Marmora Foundery Company, passed 16th March, 1831.

[16] Twelve hundred acres of the land in fee was purchased from a private owner (C. A. Hagerman), and the rest was acquired by grant from the Crown. Report of the Commissioners on the Removal of the Penitentiary from Kingston to Marmora, appendix to Journal of the Assembly of Upper Canada, Session 1839, vol. II, pp. 239 and 245.

Mr. McGill on this property in his offer to the Commissioners was £25,000, including the land, and if the statements made by the Commissioners were trustworthy the wonder is that the works should have been allowed to remain idle.

The Big Ore bed in Belmont.

Referring to the supply of ore at the Big Ore bed, they describe it as a mountain on the shore of Crow lake entirely composed of iron ore. "Inasmuch as the Commissioners had never before a conception of such a quantity of ore in one mass in such a position, their surprise was exceeding, for the first consideration that must be given to this locality is that it is inexhaustible for all the purposes which may be forever required for this Province." They also found that with a boat of fifty tons navigated by four men one hundred and fifty tons of ore from the head of the lake might easily be brought to the works in two days, so readily was it quarried and put on board there.[17] The extent of this ore body is better known now, but the impression produced upon the minds of the Commissioners was doubtless an effect of novelty.

A furnace record.

As to the profits of the business, the report gave the following figures of actual cost and production as shown by the record of the new furnace for a campaign of five months:[18]

STATEMENT OF THE EXPENSES OF WAGES INCURRED IN THE WORKING OF THE NEW FURNACE, BLAST COMMENCING ON THE 15TH DAY OF DECEMBER, 1825, AND ENDING ON THE 15TH DAY OF MAY, 1826

	£.	s.	d.
To the founder, John Jones, 152 days at 15s. per diem	114	0	0
To 2 firemen, Campbell & Dyer, 152 days at 6s. 3d. each per diem	95	0	0
To the ballast moulder, Seagriff, 152 days at 5s. per diem	38	0	0
To 2 top-men or tillers, 1 banksman and 1 ore-burner at $24 per month each	120	0	0
To 1 gutter-man at $20 per month	25	0	0
To the carpenter who attended the bellows, 1s. per day extra wages, 152 days and $12 allowed for the blast	10	12	0
To the average labor of 2 men each day employed in making log-heaps, filling ore, raising clay and sand, etc., 152 days at 3s. 3d. per diem	24	14	0
To the expense of 600 bushels of coals each day for 152 days, at 21s. 6d. per hundred	980	8	0
To the average quantity of ore, 4 tons per diem, for 152 days, at 5s. per ton	152	0	0
To allowance for candles, oil, tar, etc, for the casting-house, moulding, and use of bellows, at 1s. per diem for 152 days.	7	12	0
Total expense	1,567	6	0

During the blast she cast as follows, viz:

In December	90½	pigs
January	316	do
February	341	do
March	483	do
April	466	do
May	218	do
Total	1,914½	pigs

Say 1,914½ pigs, equal to 273½ tons, which at £15 10s. Currency net at Kingston (allowing 40s. per ton, take the actual expense of transportation thither), will amount to £4,239 5s., showing the gain by the furnace in the five months' blast as follows, viz:

	£.	s.	d.
The proceeds at Kingston	4,239	5	0
Deduct the amount of expenses as set forth	1,567	6	0
Profit she has actually made	2,671	19	0

In this statement no charge is made for interest upon the capital invested. At Mr. McGill's valuation of £25,000 this would amount at 6 per cent. to

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[17] Report, p. 238.

[18] Report p. 245.

£625 for the five months, which would still show a profit made by running the furnace for that time of more than £2,000 The allowance for wages, it will be noticed, is fairly liberal even at present rates ; but 4⅓ cents per bushel for charcoal and $1 per ton for ore are low figures. On the other hand, $62.50 per ton for pig iron is nearly four times the price of charcoal pig at the present time in Michigan.

Importance of the works.

Commenting upon the statement and other facts elicited by their enquiry the Commissioners observed in their report that they "serve to show the importance of the works, if even conducted upon the moderate scale of operations upon which they have hitherto been managed, by which it appears that by the operations of only one furnace in blast for the year, and the forges making but three tons of bar iron per week, an annual profit of £13,037 18s. 6d. was estimated to accrue, after paying all the contingencies chargeable on the operations producing it, and valuing the produce at a net price under the market rates, deducting charges of transport and sale ; a profit (independent of the advantage to the country of having even so much of the supply of so necessary an article of consumption as iron furnished within ourselves) which would cover the first heavy outlay of building and otherwise preparing for the safe-keeping and accommodation of the convicts in the event of transferring them to the establishment. But the Commissioners cannot contemplate the probability of confining the operations of an establishment like this, and of one of the manufactures in the rank of utility most essential to mankind, with the unequalled privileges and advantages which the works possess, to be confined to the making of a few hundred tons of castings and bar iron every year—while the Province is annually disbursing hundreds of thousands of pounds for that commodity from abroad which could be profitably produced at home of a far superior quality and at a diminished price. Independent especially of the great importance which the establishment would prove to the Queen's Government in the time of war, as a resource to supply all the ordnance and munitions of war in their line, a resource contemplated with approbation by the Home Government when to foster the iron works into existence they gave a contract to Mr. Hayes for the delivery of pig iron ballast into the naval yard at Kingston at a full remunerating price, to the extent of £13,000 sterling."[19]

Estimates of value of the estate,

That the Commissioners showed only the bright side of the shield is apparent when the estimates of value of the estate and profits earned by the works are examined. The following statements possesses historic as well as economic interest :"[20]

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[19] Report, p. 239.—Reference to this contract is made in the Order in Council of 30th October, 1821, (p. 15 ante). In those days pig iron was largely used as ballast for ships of war, for which purpose it was cast into lengths of about three feet, with a hole at each end through which a cable was slipped to make a connected but easily shifted weight. This explains the item of £38 for wages paid to the ballast moulder in the foregoing statement. Since the era of steam navigation coal is the principal article used for ballast in war ships.

[20] Report, p. 242.—The following detailed description of the works is given in the report of the Commissioners : "The works, of which a ground view with references is herewith presented, consists of two furnaces for smelting iron ore, connected by a casting house common to both, with the wheel house and bellows house attached to each, having in the same file of building several capacious rooms and lofts, usefully occupied in the purposes of a foundry —the whole forming one solid mass of building of limestone, constructed on the face of a bank of the same material, forty feet high to the level of the bank ; on this bank (an area of five acres of which is enclosed with a dry wall) three substantially framed coal houses are built, sufficient to contain each 35,000 bushels of coal ; another portion of the same bank has hitherto been occupied as a coal and ore bank, where the ore has been usually roasted on log heaps, to free it by that process from the intermixed sulphur, and upon the unoccupied part of it much if not all the charcoal required for the uses of the furnaces could be most profitably made, as will be hereafter shown. The furnaces, as conducted formerly by private enterprise, were found capable of making four tons of iron daily, on the average ; statements in which respect they are enabled to submit by politeness of the Honourable Peter McGill, the proprietor. In connection with the furnaces is a large and substantial stone building, containing two trip

ESTIMATE OF THE PRESENT VALUE OF THE ESTATE IN THE MARMORA IRON WORKS.

	£.	s.	d.
The new furnace, being the largest, is considered to have cost in its construction, with the two apartments attached, and the complete top-house, bellows-house and wheel-house	1,000	0	0
The bellows, bellows gear, wheel and shaft cost	250	0	0
The castings-house for both furnaces cost	400	0	0
The old furnace, wheel, bellows, bellows-house, wheel-house, top-house and sparking-room, in the ratio of the other furnace	1,000	0	0
The forge-house, with four fires, two trip-hammers, containing four sets bellows impelled by water from four different wheels, and the two hammers—two different wheels—original cost upwards of £2,500; present value at the lowest estimate	2,000	0	0
Carpenter's shop, complete	150	0	0
Four coal houses, at £30 each	120	0	0
Grist mill, one run of stone, complete, and smut machine	500	0	0
Saw mill, two pit and one circular saws, complete	300	0	0
Bark mill and tannery	200	0	0
Dwelling house	300	0	0
Stone boarding house	200	0	0
New store and office	300	0	0
Rake house, old office and old store	50	0	0
The clerk's house	180	0	0
Twelve dwelling houses for men, at £60	720	0	0
Barn, stable, root house, cattle shed, ash house as a dry house, ashes, etc	150	0	0
Water lot in Belleville, value	100	0	0
14,000 acres of land, at 20s. per acre	14,000	0	0
Utensils, etc., and lower store, patterns, etc., fire engine	300	0	0
Length of flume and canal	750	0	0
The two dams and breakwater as they now stand	500	0	0
Stock of ore	300	0	0
	£23,770	0	0

and profits of the business.

The quantity of land belonging to the works was only 12,735 acres, not 14,000, and the total estimate for the property should therefore be reduced by £1,265, leaving it £22,505 or nearly £2,500 less than the price set upon it by the owner. With plant and property of this value the Commissioners made the following estimate of profits on a year's business based upon the

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hammers and four forge fires, for the purpose of making bar iron, with two wheels which trip the hammers, and four wheels that propel the bellows, one to each fire. This factory, put in active and kept in constant operation, is capable of making five tons of bar iron per week of all sizes and descriptions, and is now in a state requiring but moderate repair to fit it for immediate use.

"On the forge bank, a clear area of two acres, is another well built coal house, of equal size with those belonging to the furnaces; attached to the forges is a convenient carpenter's shop, sufficiently capacious to accommodate five workmen, with a lathe and grinding stone impelled by water, the upper loft of this shop forming a convenient and spacious moulding and framing room for moulding, planning and putting together large patterns and moulds; opposite and at a convenient distance between the furnaces and forges stands the general pattern store, and occupied besides as a casting and bar iron sale and deposit store, a good frame building, built on a solid foundation on the water's edge.

"Next on the falls occur in their order the blacksmith's forge, suited for two smiths, with benches and utensils complete; a bakery, the baker and miller's house, adjacent to a respectable grist mill, the under story ot stone, the upper handsome, substantial, well-finished framework, one run of stone and a smut machine; contiguous to which is a superior saw-mill, newly built, with two pit saws and a circular saw; and near thereto on a small island, a situation admirably adapted for the purpose, is a substantial two-story building—under story stone, the upper story frame work, fitted into a most complete tannery, with vats, utensils and bark mill complete; added to these are several very valuable dwelling houses, some of them stone—a stone store and offices—a barn, barnyard and sheds, forming in the view of the Commissioners a more complete and substantial establishment than on its scale of magnitude can be met with in all North America." pp. 236-7.

working of the new furnace for a campaign of five months, allowing each furnace to continue in blast only six months of the year.[21]

	£.	s.	d.
Semi-annual profits of the new furnace	4,029	16	10
do do old furnace	2,442	10	10
Profits on sales of merchandise, provisions, etc., per annum	1,060	0	0
Profits on 156 tons bar iron	1,423	10	0
And that valued upon the farm	200	0	0
Total yearly revenue	9,145	17	8

The first of these items is calculated upon 328 and the second upon 225 tons of pig iron converted into castings, at £20 per ton. But the particulars are not very satisfactory. They afford good ground for criticism, and it may be presumed that the Government of the day was not dazzled with a prospect of making 36 per cent. profit on an investment of $100,000, or even 40 per cent. on $95,000, the Commissioners' valuation of the property and works.[22]

One member of the Commission (Isaac Fraser of Ernestown), who presented a minority report, appears, while persuaded of the value of the plant and the importance of the industry, to have seriously doubted the wisdom of the Government's engaging in the business.

Reasons against Government undertaking the business with convict labor.

"Without offering an opinion on the present value of the establishment," he stated, "the undersigned is fully persuaded that it possesses very great facilities and advantages for the extensive manufacture of iron, and that a more eligible situation for that purpose cannot be selected in this Province; but whether the manufacturing of iron on the public account and at the public cost, in preference to leaving that, as well as all other branches of industry, open to the free competition, skill, enterprise and capital of such individuals or companies as may wish to engage in the same, will be for the Legislature in its wisdom to decide. The principal object in transferring the penitentiary from Kingston to Marmora would seem to be the employment of convict labour, so as not to interfere with the pursuits of the honest mechanics of the Province; but if this object can be equally well attained at the present establishment, it is evident that the loss of the large amount already expended on it will be avoided, and the necessity of a further large outlay would be prevented."[23]

These views, and the representations of the warden of the penitentiary on the difficulty of maintaining discipline over the convicts, the necessity which would arise for employment of extra keepers to prevent their escape, the unsuitability of men with constitutions impaired and destroyed by intemperance and other excesses for hard labor, and the greater cost of maintaining a penal institution, whose inmates would be thus employed in an isolated location,[24] appear to have convinced the Government that the project could not be carried out.

VanNorman's venture at Marmora.

Nothing further seems to have been done with the Marmora works until 1847, when the property was purchased by Joseph VanNorman, of the Charlotteville furnace, for $21,000. Mr. VanNorman spent a large sum in repairing and improving the works, and began making iron in the summer of the following year. But he had no skill in treating hard magnetic ores, and all his efforts were attended with disappointment and loss. Shipments of product were made at first over a rough waggon road to Belleville, a distance of thirty-two miles ; but by cutting nine miles of road from the mine at Crow lake to Healy's falls on the Trent river a new land and water route was obtained whereby, although bulk was broken three times, pig iron could be delivered at Cobourg more easily and at less cost than at Belleville. Sales were made for a short time at $30 to $35 per ton ; but after the construction of the St. Lawrence canals British iron could be brought up the country and sold at a much lower rate, and Mr. VanNorman was compelled to close his works with the loss of everything.

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[21] Report, p. 247.

[22] One of the Commissioners who signed this report was Anthony Manahan, a charter director of the Marmora Foundery Company. George N. Ridley was the other.

[23] Report, p. 249. [24] Ib. p. 255.

A new company organized, and a large fuel reserve acquired.

In July, 1849, Mr. McGill conveyed the lands at Marmora which he had acquired from Mr. Hetherington in 1834 to the Marmora Foundery Company, and in 1853 this company was reconstructed under an amending charter and a capital of £80,000 stg. "to carry on extensively the manufacture of iron and steel." Among the new directors were A. T. Galt, Peter McGill, Alexander Simpson, William C. Evans and James B. Greenshields of Montreal; William Rhodes and Edward Burstall of Quebec; Robert Gillespie of London, and W. A. Matthews, mayor of Sheffield, Eng., and it was provided that the Act should not go into operation until £30,000 was paid in. Little is known of the affairs of this company until 1856, when it applied to purchase at a reduced price 20,000 acres of land as a fuel reserve. The matter was brought to the attention of the Legislature in the session of 1857, and the following resolution was adopted :

"That it is expedient to encourage the manufacture and production of iron in this Province, and for that purpose to allow the Marmora Iron Company to purchase for a fuel reserve waste lands of the Crown in the townships of Marmora, Belmont and Lake not exceeding 20,000 acres at the price of not less than one shilling and sixpence currency per acre."[25]

Amalgamation with the Cobourg and Peterborough Railway Co.

Mining operations resumed.

The property sold by order of the court.

An Order in Council of 20th October, 1857, authorised the Commissioner of Crown Lands to carry out the sale to the company at thirty cents per acre, although the price of public lands in the Province at that time, as fixed by regulation, was eighty cents per acre. Patents for 15,000 acres of this purchase were issued in 1863, and for 4,800 acres in 1872 ; but in the meantime the company had become amalgamated with the Cobourg and Peterborough Railway Company, under the title of the Cobourg, Peterborough and Marmora Railway and Mining Company. The deed of amalgamation between the two companies was signed December 28, 1866, and in the following year mining operations were resumed at Big Ore bed[26] and shipments of ore began to be made to Cleveland and Pittsburgh *via* Cobourg. A section of railway, eight miles long, was built from the mine to the Narrows on the Trent river, whence the ore was taken by boat to Harwood station on Rice lake, and again put on cars for Cobourg. The shipping season did not last more than four months of a year, owing to difficulties of river navigation, and during this period about 100 tons per day were moved from the mine. The books of the company are destroyed, but there are records to show that 12,205 tons were shipped in 1870, and 10,100 tons in 1873, the last year in which the mine was worked. None of the ore raised by the new company was smelted in the Province, and of course the timber reserve of 20,000 acres acquired from the Government was not used for the purpose for which it was intended. Some time before closing down the mine the company had bonded the whole of its property for $300,000. In 1883 the whole property, including railways and rolling stock, mines, furnaces and works, dwellings at Blairton and Marmora and about 30,000 acres of land, were offered for sale by direction of the court, and Mr. T. P. Pearce of Cobourg (now of Toronto) became the purchaser, at the nominal price of $32,200. Mr. Pearce is still the owner, but the Big Ore bed at Blairton is filled with water, and the furnaces and works at Marmora are tumbling into ruins.

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[25] Journals, 1857, vol. xv. p. 438.

[26] The name of Big Ore bed was changed by the new company to Blairton mine, and forty cottages were built for housing the employés.

A BLAST FURNACE AT MADOC.

Another unsuccessful venture in Hastings.

A furnace for smelting iron ore with charcoal fuel was built at the village of Madoc in 1836 or 1837 by Uriah Seymour, and was worked with varying success for eight or nine years. The mine which supplied this furnace with ore is known as the Seymour mine, and is on lot 11 of the fifth concession of Madoc. Mr. F. E. Seymour, son of the furnace owner, gave the following account of the enterprise to the Commissioners appointed to enquire into and report upon the mineral resources of the Province:

"My father had a foundry as well as the furnace, and they began the manufacture of those articles at once. There were several tests or experiments made with the ore, as it required different treatment to that of ores he had been accustomed to in York State; it contained neither phosphorus nor sulphur. I think smelting went on till 1844 or 1845. The experiments were very expensive, but I think the real cause of the stoppage was a lawsuit, together with a sudden drop in the price of iron. My father produced very good metal, and he said it was a very good ore to work when he got the proper flux. He mixed no other ore with it at all, but put loam with the flux, and this he considered to be the secret of his success."[27]

A fuller account of the difficulties experienced in working this furnace has been given by Mr. Thomas Macfarlane in the report of the Geological Survey, from information which the writer obtained from Mr. Seymour himself.

A record of furnace experiments.

"Limestone was used as a flux, and three different blasts were started with different materials (found in the neighborhood) for hearthstones. In each of these three trials the hearthstone was rapidly cut out by the slag, the furnace became unworkable and was blown out, always at a great expense for repairing the furnace and for fuel in heating it up. Mr. Seymour, supposing the bad quality of the hearthstones to be the cause of these misfortunes, procured a new hearth from Rossie, in New York, of the material used in the furnaces there. The furnace was again started, but, by way of precaution, with a blast at only one tuyere. The same flux was used as formerly, and the same slag was produced, cutting into the Rossie stone as much as it had ever done into the hearthstones previously used. It having been thus demonstrated that the former hearthstones were not at fault, since even the Rossie stone could not withstand the slag, Mr. Seymour decided to alter the flux, substituting for the limestone a sandy clay. This was done, the blast was stopped at the damaged tuyere, and introduced at the one which had been kept unused. Very soon the character of the slag changed. It became mild, did not cut into the hearthstone, and kept fluid and in motion long after it left the furnace. The iron was of excellent quality, but at this time the stock of charcoal became exhausted, it being impossible to procure charcoal burners to keep up the supply. Reduced to extremity, Mr. Seymour caused cordwood to be sawed up into lengths of two feet and used instead of charcoal. For seventy-five days he continued to work his furnace with the same fuel; and with only one tuyere, producing a good slag and excellent iron to the extent of one ton daily. About eighty tons were produced in all during the blast and cast into stoves, potash-kettles, etc., besides a small quantity of pig iron. The latter found a ready sale in Belleville at $27 per ton and was considered of first-rate quality for machinery. Encouraged by his success in smelting with wood, Mr. Seymour repaired the furnace and started it again with wood alone as fuel, and with the two tuyeres at work. From two to two and a half tons of iron were produced daily, but it was of an inferior quality; the castings made with it cracked in cooling. Mr. Seymour was led to suspect that this was caused by the wood descending too quickly and insufficiently charged into the furnace. That this did affect the quality of the iron was proved by stopping one of the tuyeres. The daily produce sank to one and one-quarter tons, but the good quality of the iron was restored, and the furnace kept in blast three months. The exact cost of the operation I could not ascertain, but Mr. Seymour assured me that according to his books this blast contributed somewhat to improve the financial position of the concern. The daily product of iron was however too small, and smelting with charcoal was again resumed, in the midst of which Mr. Seymour's partner was killed by an explosion in the mine. The difficulty of settling with his heirs became superadded to the financial difficulties of the concern, and Mr. Seymour's means having become exhausted he was obliged to suspend smelting operations."[28]

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[27] Report of the Commission, p. 389.

The failure of Mr. Seymour's venture does not appear to have been due to the quality of the ore, but rather to the primitive methods employed and to lack of sufficient capital where costly experiments had to be carried on with an ore the nature of which was not perfectly understood. The use of earth instead of limestone for flux seems to have been attended with very satisfactory results, a knowledge of which may prove to be valuable in the future treatment of our dense magnetic ores. From data furnished by Mr. Seymour to Mr. McFarlane it appears that he was able, even by the methods he employed, to produce pig iron with cordwood as fuel at a cost of $12 per ton.

BLAST FURNACE IN ESSEX COUNTY.

Smelting bog ore in Essex county.

A furnace to smelt bog ore was erected in 1831 by Messrs. Cahoon & Field at what is now known as the hamlet of Olinda, in the township of Gosfield. A passing reference to this enterprise is made in Smith's Canada, where it is stated that ore was found in the townships of Colchester and Gosfield, "large quantities of which used formerly to be manufactured at the furnace in Gosfield."[29] But this furnace is little more than a tradition even in the locality where it stood, and the few notes given here have been gathered from the old residents. The height of the stack was about thirty feet and the furnace is said to have been driven by a cold blast through one tuyere, but its daily capacity is not known. Sufficient quantities of ore were obtained within a radius of five miles, being chiefly of a variety known as "shot" ore, and it was smelted with a mixture of hardwood and charcoal. Stoves, plows, potash kettles, etc., for the needs of settlers were made at a foundry in connection with the furnace, but the principal market for the pig iron was found in the United States. There are no records to show what quantity of iron was produced by this furnace, nor the price at which the pig iron was sold. After having been in operation six years it was blown out in 1838, tradition says, "for want of funds."[30]

Experience of iron making in Quebec.

More than the lifetime of a generation has passed since the last pig iron was made in Ontario. Quebec has had a more fortunate experience, and a lesson of instruction to us may be found in it. I purpose therefore to follow the story of iron making in Ontario with some account of the production of pig iron from bog ores as carried on at the two seats of the industry in Quebec, in the valleys of the St. Maurice and St. Francis rivers. During the months of August and September of last year I visited the works at Radnor and Drummondville, and in February of this year I made again a hurried visit to Radnor along with members of the International Mining Convention. My information therefore has been obtained at first hand from the managers and officers of the works and from observations on the ground.

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[28] Report of the Geological Survey, 1866, pp. 109-111.

[29] Smith's Canada, vol. I. p. 27.

[30] For the information about the Olinda furnace here given I am indebted to Mr. Grove Whaley, a farmer in the township of Gosfield. "My father, Mr. Henry Whaley, now deceased," Mr. W. writes, "was foreman during its existence. I am too young to remember anything concerning it, being only fifty-five years of age. But I have interviewed some of the old residents here who are supposed to know, and am sending you what facts I can gather."

THE ST. MAURICE FORGES.

Furnace at St. Maurice village.

The group of furnaces known generally as the St. Maurice forges, from their situation on and near the river of that name, are five in number, and are in the counties of St. Maurice and Champlain. The oldest of these is at St. Maurice village, and has the name of being the second blast furnace on this continent, having been erected not later than 1737, and possibly four years earlier. The first furnace in America was built some years before this time by Governor Spotswood of Virginia, an interesting account of which is given by W. N. Adams in a recent number of the New York Iron Age,[31] who in November of last year exhumed it from the mass of debris, soil and vegetation which had buried it from human sight for one hundred and fifty years. The St. Maurice furnace, after an eventful history of nearly a century and a half, was blown out in 1883, having for the last twenty years of its existence been worked by John McDougall and his son George, and by the firm of John McDougall & Co. of Montreal. When John McDougall purchased the works in 1863 they consisted of one blast furnace and two Catalan forges. The hearth of the furnace was three feet square and four feet high, the diameter at the bosh was 8 feet 2 inches, and the height of the stack from the bosh to the throat was 20 feet. At first it was driven with a cold blast, but in the later years by a warm blast. The ore and charcoal were obtained in the immediate neighborhood, and about four tons of pig iron was produced daily. For three or four years the pig metal was cast into stoves, kettles, etc., but after 1866 the whole product of the furnace was sold to and used by John McDougall & Co. of Montreal for car wheels.[32] In 1874 the works were purchased by John McDougall & Co., and were carried on for about ten years longer, when the furnace was blown out for the last time owing to the scarcity of ore and fuel in the locality. The Catalan forges had been worked by John McDougall only two or three years. Their product was used in the manufacture of axes at St. Maurice, and of scythes at an establishment in Ontario.

Batiscan, L'Islet and Shawenegan furnaces.

Three of the other furnaces in the St. Maurice valley were the Batiscan, on Batiscan river, built in 1798, the L'Islet, and the Shawenegan, all of which are now idle. The Shawenegan furnace was a venture to smelt lean ores containing 10 per cent. of titanium, and was a complete failure. The L'Islet furnace was built by John McDougall at a distance of four miles from the old St. Maurice works. It also turned out a failure, as without railway facilities supplies of ore could only be got within the limits of carting distance, and after a few years the local fields were exhausted. Besides, the cost of carting pig iron to the market at Three Rivers left no profit to the producer.

THE FURNACE AT RADNOR FORGES.

Furnace at Radnor.

The furnace at Radnor Forges is situated on the river Au Lard, distant fifteen miles from Three Rivers. The pioneer of the industry at this place was Mr. Larue, an intelligent and enterprising French-Canadian, who conducted the business against heavy odds for several years. The works were commenced in 1860, and when completed the plant embraced a blast furnace with a capacity of from three to four tons per day, rolling mills, a foundry for casting stove plates, car wheels, etc., and a factory for horseshoe nails, part of which was located at Three Rivers. The township was largely bushland, and roads had to be cut and made over which to bring in material for construction, supplies of fuel, ores, etc., and to carry out the products of the works, the nearest marketing and distributing point being at Three Rivers on the St. Lawrence. Under such circumstances it is little wonder that Mr. Larue's enterprise failed. His estate passed into the hands of G. B. Hall & Co., who undertook to carry on the works as a side business with lumbering. This firm retained possession until July, 1889, when Drummond, McCall & Co. of Montreal became the purchasers, and organized the Canada Iron Furnace Company with an authorized capital of $300,000. The property consists of the furnace and charcoal works with 80 acres of land at Radnor, a car-wheel foundry at Three Rivers, mining rights on about 100,000 acres of land (embracing the township of Radnor) which had been granted to Hall & Co. by the Local Government, and an extensive tract of timber land along the St. Maurice river above Grand Piles. The furnace was leased for a short time to George McDougall, and operations were carried on until May, 1891, when it was blown out and dismantled, and the erection of a new furnace was commenced under the management of Mr. John J. Drummond, with designs prepared by John Birkinbine of Philadelphia, president of the American Institute of Mining Engineers. The shell of this furnace is constructed of boiler-plate, with a diameter of 13 feet 6 inches from the mantle ring to the top. The total height from the hearth floor is 40 feet, the crucible has a diameter of 5 feet and height of 4 feet 8 inches, the bosh a diameter of 9 feet and height of 8 feet 4 inches, and the stack proper a height of 27 feet with diameter of 9 feet at the bosh and 6 feet at the top. The furnace is water-jacketed from the base of the crucible up to the bosh-line, the jacket consisting of sixteen sections of cast-iron plate about 2¼ inches in thickness, through which runs a coil of one-inch pipe, the plate having been cast around the coil in the mould. Half a million gallons of water flows through these pipes every twenty-four hours, whereby the temperature of the interior fire-brick wall is kept down and its life preserved. The tuyeres, four in number and 3½ inches diameter, are water-jacketed also, and the hot-blast is driven into the furnace with a pressure of 3¾ lb., at a temperature of 850° F. So equipped the furnace had a capacity of 25 tons of pig per day of 24 hours. With a new Weimer blowing engine and four boilers now set up and working it is believed that the furnace can be driven up to 50 tons per day, but owing to a short supply of charcoal fuel the daily output during the winter has been limited to 25 tons. In practice the make will probably not exceed 40 tons per day. Gas from the stack furnishes fuel for the boilers and hot blast stove, and the supply will doubtless be ample when the furnace is driven to its full capacity.

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[31] New York Iron Age, April 13th, 1893, p. 843.

[32] The head of this firm, it may be remarked, is not the John McDougall of St. Maurice, nor even a relative of that gentleman.

A modern furnace built by the Canada Iron Furnace Company.

The blast was started in the new furnace on 12th March, 1892, and it is hoped that the campaign can be carried on for two years before closing down for repairs. For the first twelve months 6,500 long tons of pig iron was produced, the quality of which is claimed to equal the famous Salisbury brand.[33]

Supplies of bog ore.

The ore supply for the Radnor furnace is procured from a number of sources on both sides of the St. Lawrence, and consists almost wholly of bog ore or brown hematite. Magnetic ore from the Bristol mine on the Ottawa river is used as a mixture in small quantities, but it contains sulphur and requires to be roasted. Farmers are employed during the slack season in raising ores on their own or the company's lands and either drawing it to the furnace or delivering it at the nearest railway station. A large quantity is raised by the company's employés at Lac-a-la-Tortue on the line of the Grand Piles railway, nine miles from Radnor, where after being dredged and washed it is loaded on cars and taken to the furnace. This lake has been worked for thirty-one years, and although it only covers an area of five square miles the supply is believed to be still very large. In places the ore lies two feet in thickness, and where streams enter constant addition is being made to the deposit, the particles of iron being washed out of the sand area southward of the Laurentian hills. The following analyses of bog ores used at the furnace have been made by Prof. J. T. Donald of Montreal:

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[33] The St. Thomas Car Wheel Co. is now using 2,000 tons of Radnor pig iron a year. They volunteer the testimony that it is giving most satisfactory results in their car wheel mixture. "We have found that by the aid of it we can entirely dispense with the high-priced irons which we were formerly obliged to import, our records of tests showing an improvement of over 25 per cent. on the results previous to using your iron, in addition to which our percentage of loss has been greatly reduced." The Waterous Engine Works Co., of Brantford, report after two years trial that for cylinder and valve castings for engines it is at least equal to if not better than Salisbury iron, which they had previously used for this purpose.

——	1	2	3
Metallic iron	49.03	42.52	50.49
Manganese	1.78	1.18	0.23
Alumina	2.50	2.59	
Lime	0.32	3.47	
Silica	7.84	13.94	3.53
Phosphorus	.33	.302	.566
Sulphur	.09	.078	.15

The ore is very fine, yet it smelts freely and little of it is lost by blowing; but possibly the loss will be greater when the furnace is worked under higher pressure.

Production of charcoal fuel.

Charcoal is made partly at the works and partly at Grand Piles in kilns of rectangular and bee-hive forms, the latter being preferred. In the furnace yard there are eight rectangular and three bee-hive kilns, each having a holding capacity of 55 cords. At the Piles there are ten kilns, and five others are to be added. The supply of fuel there is practically inexhaustible, as the territory lies 70 miles along the St. Maurice river above the falls, and the Company has a right of cutting four or five miles back on either side. There are no obstructions on this stretch of the river, and the wood may be taken down in boats to the kilns at very low cost. About thirty per cent. of the coal is made from soft wood and seventy per cent. from hard wood, chiefly black birch and maple. The weight averages 22½ lb. per bushel and 110 bushels are required to smelt a gross ton, or say 98 bushels for a net ton of 2,000 lb. Much difficulty has been experienced in procuring help for the charcoal woods, owing to the exodus from that part of Quebec, and the company has a standing advertisement in the papers for a hundred men. Late last year twenty-five men were brought out from the charcoal-making districts of Sweden, and an effort is being made to bring out a hundred more this year. The Swedes have adopted a method of charcoal-making employed in their own country which may possibly lead to an important change in the company's fuel works. The timber is cut into lengths of ten feet, and after being rolled into heaps in the woods it is covered with earth and charred in the old-fashioned way. Constant additions however are made to the heap at one end, while from the other the finished charcoal is drawn out and carted off to the railway station or to a landing on the river. If this plan is found to be satisfactory it may supersede the kilns, but the company will no doubt be guided in its course by the results of careful comparison.

Means for preserving the fuel supply.

It has been stated that the company's fuel supply on the St. Maurice is inexhaustible; yet it is not proposed to deal recklessly with that heritage. On the contrary, the intention is to take no tree for charcoal-making under

12 inches diameter, and all parts of it down to three inches will be utilized,—and to lessen the risk of forest fires the smaller branches and brushwood will be gathered into heaps and burnt in the spring or early summer of each year. By pursuing this plan it is confidently hoped that a continuity of fuel supply will be preserved upon a limited area along the river, and that there need be no fear of increase of cost on account of long haulage for many years.

Labor employed at the works.

The Radnor furnace gives employment to a large number of men, some steadily but most of them irregularly, as they are farmers who employ their spare time in raising ore or cutting wood upon their own lands and drawing it to the company's works or the nearest railway station. Sometimes the total reaches 850. The average of the past year was 600, but some of these were employed opening up new fields of ore and on work of a preparatory character, so that in proportion to the production of the furnace the number was larger than will be found necessary hereafter. But with the increased capacity of the furnace a large force will be required, especially in the ore fields and in the woods. The wages of ordinary laborers range from 80 cents to $1 per day, of furnace laborers from $1.15 to $1.40 per day, and of furnace men from $75 to $100 per month.

THE ST. FRANCIS FURNACES.

In the St. Francis valley, on the south side of the St. Lawrence, iron-making has been in progress for nearly a quarter of a century.

Locations of furnaces.

The first blast furnace in this district was built in 1869 on the Aux Vaches river, a tributary of the St. Francis, in the county of Yamaska. It was operated by the St. Francis River Mining Company for four years, during which 5,520 tons of pig iron was smelted from the bog ores in the locality, and in 1873 it was sold to John McDougall & Co. of Montreal. By this firm the works were carried on until 1880, when, upon the ores becoming exhausted, the furnace was dismantled.

In 1880 the same firm began to establish smelting works at the town of Drummondville, on the St. Francis river. One furnace, known as the Grantham, was built in that year, and a second, known as the St. Francis, in 1881. Both stacks are built of stone lined with fire brick, on four arches which form a square of 26 feet, and both are about 35 feet high. The bosh of the Grantham is 10 feet in diameter and that of the St. Francis 9 feet, the capacity of the former being 7 tons and of the latter 6 tons per day. Both furnaces utilize gas from the stack to heat the blast, the temperature of which is 400° to 450° F. The blowing cylinders are driven by a Leffel wheel of 56 inches diameter, and the pressure ranges from three-quarters to one pound per square inch. The blast is driven into each furnace through five tuyeres of $1\frac{1}{2}$ inch diameter.

Supply of bog ore.

Bog ore is obtained from the districts south and east of Drummondville, at distances ranging from four to twelve miles. The bulk of it is raised by the firm's employés, washed by seiving in shallow wells, and drawn to the yard by the firm's own teams; but considerable quantities are gathered and delivered by farmers and jobbers. As washed this ore will analyze 50 per cent. of metallic iron, and yields in the furnace 40 to 42 per cent. When drawn by teams direct to the furnace it costs $1 per 1,000 lb., and when brought in by rail $1.25. Farmers on whose land the ore is mined are paid by the firm a royalty of $7\frac{1}{2}$ cents per 1,000 lb., or 15 cents per short ton, which is equivalent to about 38 cents per ton of pig. The ore occurs in beds ranging from 3 to 12 inches in thickness, and sometimes to 20 inches. It is found in the sand or on the edges of bogs, on islands in the bogs, and occasionally in peaty deposits.

Charcoal fuel.

The charcoal for fuel is made in rectangular kilns on the furnace grounds from balsam, spruce and small quantities of white birch and soft maple, at a cost of about five cents per bushel. Wood for the purpose is delivered at

$1.25 per cord of 138 cubic feet, this being the French measure. Twenty-five bushels of coal is sufficient to smelt 650 to 700 lb. of ore, which is the usual charge for the furnaces.

The average length of a campaign is about ten months, at the end of which time it is found that the lining of the furnaces is in need of repairs; but both furnaces are hardly ever shut down at the same time. The whole output is used in the manufacture of car wheels at the company's works at Montreal, where it is regarded as equal to the production of the Salisbury furnaces. Sometimes large stocks accumulate, the quantity of which is determined by the requirements of the car wheel foundry. At the time of my visit in September about 2,500 tons of pig was piled up in the stock yard, although it might then be sold to dealers at $27 per ton.

Employment of labor.

With one furnace in blast 36 men are employed, and with the two 44 men. In the bush an average of 150 men is maintained for the year round, making ore, wood and limestone. The stone is obtained in the township of Grantham, about four miles from the furnaces, and 40 to 50 lb. is sufficient flux for a charge. The highest wage paid at the furnaces is $1 per day, and the average is 90 cents, which with a free house makes a round rate of $1. In the bush men taking out ore are paid $1 per day, and axemen are paid 50 cents per cord. In round numbers those two small furnaces at Drummondville give employment to 200 men, whose earnings in a year are $60,000.

THE BOUNTY ON PIG IRON.

Rate of the Government bounty.

With the object of encouraging the production of pig iron in Canada the Dominion Parliament ten years ago adopted the bounty system, and provision was made for the payment of $1.50 per ton of 2,000 lb. This bounty was continued until the end of the fiscal year 1888-89, when for the next three years it was reduced to $1 per ton. Beginning with 1st July, 1892, the rate was increased to $2 per ton, and payment of bounty at this rate has been authorized for a period of five years.

The following table gives the quantity of coke and charcoal pig iron made in the Dominion in each fiscal year since provision was made for payment of the bounty, and also the amount of bounty paid as shown by returns made to Parliament, the weight being expressed in tons of 2,000 lb.:

Year.	Coke Iron.		Charcoal Iron.		Total Pig Iron.		Bounty paid.
	tons.	lb.	tons.	lb.	tons.	lb.	$
1883-4	25,472	0399	3,855	1797	29,328	0196	44,089.91
1884-5	21,174	0166	4,595	1135	25,769	1301	38,654.91
1885-6	22,463	1426	3,715	1770	26,179	1196	39,269.56
1886-7	35,464	1520	7,255	1178	42,720	0698	64,081.41
1887-8	16,120	1888	4,646	0329	20,767	0217	31,151.58
1888-9	20,413	1200	4,404	1880	24,818	1080	37,233.27
1889-90	20,775	0048	2,594	0952	23,369	1000	25,697.27
1890-1	15,849	1632	4,303	0515	20,153	0147	20,153.05
1891-2	26,066	0528	4,228	0306	30,294	0834	30,294.37
1892-3 to Feb. 3.	24,678	0284	5,770	1870	30,458	2154	57,952.83
Totals......	228,478	1091	45,370	1732	273,849	0823	388,578.16

Coke iron.

All the coke iron in the first nine years was produced at one furnace, that of the Londonderry Iron Co. of Nova Scotia; but since the opening of the present fiscal year another furnace has commenced to make coke iron in that Province, viz: the New Glasgow Iron and Coal Co., which has produced 6,130 tons, and has been paid a bounty of $12,260 thereon. The Londonderry Company on 222,348 tons has been paid in bounties $309,886. For the first nine years its average yearly make was 22,644 tons (or 62 tons per day), and the average yearly bounty was $30,575. The statistics of those nine years do not afford evidence that production was encouraged by the bounty. In the last two years during which $1.50 per ton was paid the output was less than in the first two years under which the bounty was $1 per ton, while in the third year of the lower bounty the output was greater than in any except one of the preceding years. The present year promises a considerable increase, which may be due to the larger bounty now paid; but production will always be more influenced by the conditions of the market than by the rate of Government bounty.

Charcoal iron.

The charcoal iron is wholly the product of Quebec furnaces, viz.: of the two at Drummondville and the one at Radnor Forges, the latter having made in the whole period 12,464 and the former 32,906 tons. During the first nine years the Radnor furnace produced 8,474 tons, upon which it received a bounty of $10,686; but its product to February 3rd of the current fiscal year, with the new furnace in blast, has been 3,990 tons, and the bounty paid has been $7,081. The Drummondville furnaces produced in the first nine years 31,126 tons, upon which a bounty of $44,762 was paid. The average yearly make of these Drummondville furnaces for the nine years was 3,458 tons, ranging from 2,070 tons in 1889-90 to 6,495 tons in 1886-7. It will also be noticed that the largest production of coke iron was in the last named year. Another charcoal furnace has been started in blast this year in Nova Scotia, but the table does not include any portion of its product.

Ontario is a large consumer of the coke and charcoal irons made at those furnaces, and she imports large quantities from Great Britain and the States besides. But although she has great deposits of iron ores within her own borders, and extensive forests of timber suitable for the making of charcoal fuel, as well as much capital waiting for investment, she does not produce a ton of pig iron to supply her own large needs.

ADVANTAGES OF PRODUCTION IN ONTARIO.

The bonus and the tariff duty.

The duty imposed by the Canadian tariff on pig iron is $4 per ton of 2,000 lb., and the bounty given by the Dominion Government to the owners of blast furnaces producing pig iron from native ores and with native fuel is $2 per ton. The Canadian ironmasters therefore enjoy an advantage in their own market over foreign competitors (in which of course the British ironmaster is included) of three-tenths of a cent per pound, or $6.72 per long ton, which is the rate of protection afforded by the United States tariff. In Quebec and Nova Scotia this is regarded as sufficient encouragement for the industry, and in the opinion of some practical men who know conditions in this country and who have a full knowledge of the cost of producing pig iron in the neighboring States, the charcoal iron industry would seem to require no further aid in this Province. We have abundance of hardwood timber suitable for making the finest quality of charcoal fuel; and in the same forests, convenient to lines of railway already built, we have extensive deposits of iron ores, several of which have been opened and could be worked again at little or no cost for machinery and development. But the cost of production varies so much at different furnaces that it would be impossible to say with certainty what that cost might be at any given point in Ontario. This can be determined only by actual practice; and so much depends on the skill of workmen, the business capacity of managers, the suitability of a furnace to do economic work, the cost of assembling ore, fuel and flux, and various other considerations, that it would be useless to enter upon a discussion of the question of cost in the abstract. Practical men will investigate for themselves. Past experience in this Province is of some value, but chiefly for the lessons which it affords of practices to be shunned. Lessons of more value may be gained from the experience of ironmasters in Quebec and Nova Scotia in our own country, and many more from the experience of iron-

Favorable conditions for producing charcoal iron in Ontario.

masters in the United States. It is not for the lack of capital that there are no blast furnaces here, but rather for lack of men with confidence and enterprise to invest their money in the business of iron-making as they do in other manufactures, in trade, or farm lands, or bank stocks, or corner lots. They have been educated to invest money along these lines, and they know that within certain limits they may do so securely. The time will come no doubt, if it has not already arrived, when men with capital will turn their attention to the great dormant resources which Ontario possesses in its belts and beds of iron ores and forests of hardwood timber, and some will be found with courage to venture their money in starting an industry. But before embarking in the enterprise they will satisfy themselves by enquiry that the conditions of success are favorable; and although there may be disappointments, the experience of the world proves that it is by such men industries are built up. Self-reliance is of infinitely greater value to a business man than the best devised scheme of Government bounty alone can be; and there are many who believe that the bounty on pig iron provided for by the Canadian Government, in connection with the measure of protection afforded by the tariff, is ample in its liberality. Australia at the present time is passing through a severe commercial crisis, and the Melbourne correspondent of the London Times, in writing of the situation to that paper, opens his letter with this observation: "In order to understand the present position of Victoria, you have but to remember," some one said to me the other day, "the habitual attitude of the native-born Australian, who, wherever he stands, must lean against a post." And the correspondent remarks that the more the financial situation of that country is studied the more profoundly true the observation will appear. The depression through which Victoria is passing, he says, is to be described in general terms as the outcome of leaning against posts instead of trusting to the natural power of standing upright and depending on one's own energy and resources. It is to be hoped that no comment of this sort will ever be necessary in describing the Ontario man; but if he is taught to rely on subsidies and bonuses instead of upon his own skill and enterprise, he also may come to possess that fatal weakness of the back which needs the support of a Government post. There are ways doubtless in which Government help can and should be given, the most natural and useful of which would appear to be the collecting and publishing of information on all the natural resources of the country, and on the best economic methods whereby raw material may be utilized and converted into finished article, to the mutual advantage of producer and consumer.

Need of self-reliance and enterprise.

Best form of Government help.

Diversity of production an element of commercial prosperity.

Thirty years ago the industries of Ontario were few in number, the main sources of wealth being the wheat and barley grown by the farmer in the frontier and the lumber and timber sawn and cut by the lumberman in the backwoods. Then the failure of a grain crop or an overstocking of the lumber and timber markets was a serious matter to the trade and commerce of the country; and in Australia today the situation is much the same, with wool-growing and mining as the chief industries. But now we have a diversity of industries; in agriculture alone the variety of products gives evidence of surprising development, and to this diversity we owe in very large measure our immunity from commercial and financial distress. To open up and work our deposits of iron ore, to build blast furnaces and smelt ore into iron, and to manufacture iron into the endless forms for which it is required in the service of man, would be to make an important and substantial addition to the diversity of our industries, and so to broaden the foundations of the country's prosperity. But no new enterprise ought to be undertaken rashly. "Make haste slowly," is a good maxim in every human undertaking. The gourd which came up in a night to shelter the head of an angry prophet, a worm smote it, and it perished in a night.

III.

THE IRON ORES OF ONTARIO.

Extent of the mineral-bearing formations in Ontario.

The Laurentian, Huronian and Cambrian formations constitute the whole northern portion of the Province from the Ottawa river to Lake-of-the-Woods, saving portions of the Moose river basin towards James bay, where there is an outcropping of the Devonian. They form the whole region from Lake-of-the-Woods to lake Superior, the northern and eastern shores of the latter lake as well as of lake Huron, and nearly the whole country thence eastward to the Ottawa river and southward across the Thousand Islands in the St. Lawrence to the Adirondack mountains in New York. These are the chief mineral-bearing formations of the earth's crust, and consist of talcose and other slates, quartz rock, gneiss, limestone, serpentine, granite, syenite and other subordinate masses. The limestones and serpentines yield marbles of beautiful descriptions, the felspathic rocks furnish good porcelain clays in their decomposition, copper and nickel ores are found in several localities, veins of gold ore occur in the county of Hastings, on Lake-of-the-Woods and at a number of intermediate places, silver in various localities in the Cambrian rocks, plumbago is abundantly developed, and the whole of the older series appears to be associated with large and valuable supplies of the magnetic and specular oxides of iron. "Specular and magnetic oxides of iron are disseminated in scales and grains, both in the gneiss and the limestone; but there are also important interstratified beds of these iron ores varying in thickness from a few feet up to several hundreds, those of the magnetic oxide being the thicker and more numerous. Some of the thickest of these beds are interstratified with layers of limestone, and as far as known most of them appear to be either associated with the great limestone bands, or to be not far removed from them in stratigraphical place."[1] "The magnetic oxide sometimes occurs in masses made up of coarse grains; at other times the ore is fine grained and almost compact; more rarely it occurs in regular octahedral crystals. This ore is found only in crystalline or metamorphic rocks; and the deposits of it in Canada occur in the Laurentian series, or in the crystalline rocks of the eastern palæozoic basin. In the former it is met with in beds of great extent and thickness."[2] Professor Emmons, in his final report on the geology of New York, mentions the existence in the district bordering on lake Champlain and the St. Lawrence of upwards of seventy veins and beds of these ores, ranging in thickness from two to one hundred and sixty feet, while two others are respectively five hundred and fourteen and seven hundred feet in thickness. One of these larger beds has been followed for two and a half miles, and the amount of ore which it contains may be seen when it is stated that in a mile every five feet in depth would yield about one million tons of pure iron. Valuable deposits of the same ores have been discovered in Ontario in the townships of Marmora, Madoc, Bedford, Bastard and other places, and when we reflect upon the great extent of the mineral-bearing formations here, in so many parts of which the magnet is deflected from its meridian, presumably by the proximity of magnetic ore, it is not unreasonable to hope that search may disclose great bodies of iron ore over wide areas of territory. In the northern peninsula of Michigan and in Minnesota, where the formations are the same as in sections of Ontario north of lake Huron and northwest of lake Superior,

Specular and magnetic oxides of iron.

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[1] Geology of Canada, 1863, p. 26.

[2] Ib. p. 673.

iron ores abound on a larger scale than anywhere else in the United States, and it can hardly be doubted that a thorough search on the Ontario side would result in the discovery of the same ores in equal abundance and richness.[3]

LOGAN'S REPORT ON ORES OF THE OTTAWA VALLEY.

Ores in the Ottawa valley.

Among the minerals found associated with the formations of the Ottawa valley are the magnetic and specular oxides of iron, bog iron ore, brown ochre, galena, copper ore, plumbago, etc. In his report for 1845-6 Sir William Logan expressed the opinion that the great spread in the valley of the Ottawa of the metamorphic rocks with which the ores of iron seems to be so largely associated in other parts of its extension on both sides of the St. Lawrence makes it very probable that the banks of the Ottawa and its tributaries will be supplied with vast stores of them. In Hull, on the Quebec side of the river, a bed of the magnetic ore is met with for a distance of about one mile in syenitic gneiss, interstratified with white crystalline limestone holding mica and graphite, which varies from twenty to forty feet in thickness.[3] Where the ore has been acted on by the weather it breaks up into grains which, it is claimed, adds considerably to its value for smelting purposes. Assuming the breadth of the vein to be twenty feet, Sir William Logan calculated that every fathom forward with a vertical depth of a fathom would probably yield not less than fifty to sixty tons of pure metal. An analysis of this ore made by Sterry Hunt gave 96.09 per cent. of magnetic oxide of iron (equal to 69.65 metallic iron) and 3.18 of silica and graphite. On the Ontario side of the river ores occur in the townships of Bedford, Bastard, Sherbrooke and McNab. The Sherbrooke bed occurs on the north shore of a beautiful sheet of deep water called Christie's (or Myers) lake, and is described as containing a mass of very great importance, the bed having a thickness of about sixty feet. An analysis by Sterry Hunt gave 87 per cent. magnetic oxide of iron (equal to 63 per cent. metallic iron) and 12.08 silica and mica mechanically mixed. On the south side of the lake a bed of twelve feet of magnetic iron occurs in gneiss. Specular ore exists in the township of McNab, on the west side of Chats lake, an expansion of the Ottawa, an exposure of which showed a thickness of twelve feet, and outcroppings have been traced a length of one mile. The ore presents a red, earthy aspect on the weathered surface, but in fresh fractures it has a purplish red hue, and exhibits an aggregation of minute shining scales. There are some impurities arising from the presence of small quantities of quartz and calcareous spar, but taking the breadth at twelve feet it is probable that the bed would yield not less than twenty-five tons of pure iron for every fathom forward with a fathom in depth. A specimen analysed by Hunt gave 84.10 peroxide of iron (equal to 58.87 per cent. metallic iron) 4 of silica, 8.80 carbonate of lime and 3.10 of water by loss. "The silica and carbonate of lime" Dr. Hunt added, "are accidental impurities, and are disseminated in little spots and veins. The ore is, when pure, a peroxide of iron only."[4]

Hull mines.

Deposits in Renfrew and Lanark.

Specular ore in McNab.

IRON ORES AT THE FIRST WORLD'S FAIR.

Exhibit of Ontario iron ores at the first World's Fair,

At the World's Fair held in London in 1851 a number of specimens of iron ore from Canada were exhibited, most of which were collected by the officers of the Geological Survey. This Province was represented by the following exhibits: Large blocks of magnetic ore from Marmora, Madoc, Bedford, South Crosby and South Sherbrooke, specimens of specular ore from the Wallace mine location, and a large block from the township of McNab. There were shown also samples of pig iron made from the ores of Belmont and Marmora by the Marmora Iron Company.[5] Referring to the evidence which this collection gave of the vast supplies of iron with which the Province is enriched, Sir William Logan observed that it appeared to arrest the attention of all. The British miner who is accustomed to follow beds of ore of six inches and one foot in thickness containing 30 or 40 per cent. of iron naturally regarded with surprise great blocks of it from beds of 100 and 200 feet in thickness, yielding 60 to 70 per cent. of metallic iron; but the British smelter upon being informed that no mineral coal existed in the vicinity of the ore did not appear to apprehend that any competition would arise to interfere with the supply to Canada of those qualities of iron which are made in the United Kingdom from the deposits of the Carboniferous era. Some Sheffield manufacturers of steel, whose supply of iron was obtained from Sweden at prices varying from £10 to £33 per ton according to quality, seemed desirous of ascertaining the cost that would be required to smelt the magnetic oxide in Canada, and to them it was a question of the wages of labor rather than anything else, assuming the requisite skill to be introduced into the country, whether any competition could be established in favor of Canada, seeing that the ore and fuel in the two countries are the same. "The superiority of Swedish iron for steel is unquestionable; its character for such a purpose stands higher than that of any other country; it is made from the magnetic oxide, and between the magnetic oxides of Sweden and some of other countries chemical analysis instituted for the express purpose of comparison has, it is said, been unable to detect any difference. It might be supposed therefore that smelted with charcoal and generally treated in the same manner, there ought to be no essential difference in the quality of the iron. Experiment however does not prove this to be the case, and there may be some delicate difference (possibly the presence of rare metals in small quantities) which may yet have escaped the investigations of science, to account for the results. The ores selected for comparative trial may have been the produce of geological formations different from those of Sweden, but it is not likely that this can give the essential cause of difference, as even in Sweden the ores of different mines in the same geological formation, all yielding good steel iron, give differences of quality which are so uniform as to produce a regular and constant difference in price. The geological formations yielding the magnetic oxides of Canada and those of the United States, where they prevail in equal abundance, are identical, and it is probable they are both of the same formation as that of the Swedish mines. The practical experiments on Canadian ores are still so few that nothing can yet be proved from them. But in the United States the American smelter has been able to compete with the Swedish, only on this side of the Atlantic, and that with the assistance of a considerable protective duty." Referring to the general effect produced by the exhibit upon the minds of visitors, Sir William Logan remarked that the Canadian ores were examined with great care and attention by the agents of Russia, who were struck with wonder that such prodigious source could be found in any country but their own; while the public in general, without taking into consideration the question of present application to profitable uses, seemed to regard the great beds of magnetic oxide as national magazines in which was stored up a vast amount of a material indispensable to the comfort and progress of mankind, which it is always satisfactory to the inhabitants of a country to know is within their reach and control should circumstances arise to render its

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[3] Geological Survey of Canada, 1843, pp. 41-2. Canada possesses in the crystalline ores of the Laurentian rocks and in the iron slates of the Eastern Townships "inexhaustible supplies of rich ores of this precious metal which may compare with those of the United States or with Sweden. It is from these magnetite and red hematite ores, reduced by charcoal, that the finest iron of the world is manufactured; and it cannot be doubted that skilled labor and capital will one day make the iron mines of Canada great sources of national wealth." Geology of Canada, 1863, p. 687.

[3] According to the Geology of Canada, 1863, the thickness of this bed is ninety feet, p. 673.

[4] Geological Survey of Canada, 1845-6, pp. 75-8 and 122-3. Geology of Canada, 1863, pp. 673-4.

and Sir William Logan's report thereon.

Superiority o Swedish iron.

Effect of the exhibit on European visitors.

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[5] Geological Survey of Canada, 1851-2, p. 39.

application expedient or necessary. Referring particularly to the specimens of specular ore from the township of McNab, Sir William reported that it was regarded as "a very beautiful ore, the uniform quality of which would render it one of much more easy fusion and management than the magnetic oxides, while it would probably produce an iron of excellent quality."[6]

ORES ON THE RIDEAU CANAL.

Specular ore Bastard.

It was about this time that Mr. Murray of the Geological Survey began to examine the country along the Rideau canal, and to report on occurrences of specular iron ore in the sandstones and conglomerates of the Potsdam formation in the ninth and tenth concessions of Bastard, where it extends over a considerable area in thin layers. Although no evidence was observed of the fact, Mr. Murray expressed the opinion that in some portion of the distribution the quantity of ore might be found to increase to a productive amount. "The concentration of the ore is greatest towards the middle of the bed, where nodules and patches of pure red hematite, running with the stratification, occur at intervals of a few inches, the thickness they display not exceeding a couple of inches. About forty years since an attempt was made to mine the ore for the supply of a furnace erected at Furnace Falls, but the quantity in the locality worked was not sufficient to give a profitable result. The Potsdàm formation is similarly characterized on the twenty-third lot of the same concession of the township, and also on the ninth concession of Lansdowne, and the ferruginous deposit would thus seem to extend over a considerable area."[7] Mr. Murray goes on to say that in the state of New York an iron ore of this description occurring under similar circumstances in the same formation has been made economically available, and in those parts of the district under consideration in which a deep red color characterizes the formation it merits attention.

Magnetic ore in South Crosby.

In the adjoining township of South Crosby Mr. Murray found a large body of magnetic iron ore on an island in Mud lake, not far from Newboro on the Rideau canal, which is described as a mass of considerable purity running northeast and southwest, apparently with the stratification, and having a breadth of about seventy yards.[8] Referring to these locations six years later, Sir William Logan stated that 2,000 tons had been mined by Messrs. Chaffey of Kingston and exported to Pittsburgh by way of the Rideau canal and lake Ontario, the price on board of lake craft being $2.25 per ton. In 1854 the ore bed at Hull, on the Quebec side of the Ottawa river, was opened and mined by Messrs. Forsyth & Co., iron smelters of Pittsburgh, with the object of supplying ore to their own smelting works. It was transported from Hull through the Rideau canal to Kingston, and thence shipped by lake craft to Cleveland, but Sir William Logan remarks that as the Newbero bed was much nearer to Kingston and more favorably situated for loading into canal barges, the ore from it could be placed at the shipping port at a lower cost, the effect of which was that Forsyth & Co. began to take their supply from Messrs. Chaffey. During the season of 1859 the quantity of Newboro ore exported was 4,000 tons, making with the previous year's export 6,000 tons. "The trade in the ore," Sir William observed, "has naturally excited a keen search for other deposits in favorable positions, and Messrs. G. Chaffey and Brothers, who mine the South Crosby ore, have informed me that this search has been rewarded by the discovery of the continuation of the ore bed across the first and second lots of the sixth range of North Crosby. They have also informed me that a deposit of ore has been met with on Black

Iron ores on the Rideau canal mined and shipped to the United States.

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[6] Geological Survey of Canada, 1851-2, pp. 45-7.

[7] Geological Survey of Canada, 1851-2, p. 81. The furnace here referred to is the one mentioned on p. 13 ante, the first blast furnace built in this Province.

[8] Ib. p. 80.

lake in the eighth lot of the fourth range of Bedford, and another one on the sixth lot of the third range. These may be a continuation of the bed which has been described by Mr. Murray in a previous report as existing on the twenty-first lot of the ninth range of the same township."[9] In the Geology of Canada 1863 (p. 674) the ore of this mine is reported as forming a bed 200 feet thick, running northeast and southwest in gneiss, adjoining the crystalline limestone.

A bed of limonite or bog ore was observed by Mr. Murray on lot twenty-one in concession seven of Bastard, which was found to be about two feet thick in one place, and bounded on one side by an escarpment of rock. Dr. Hunt describes it as very pure in appearance, and an analysis showed it to contain 77.80 peroxide of iron, .061 of phosphoric acid, 16.5 water and the remainder of sand and alumina.[10]

Bog ore in Bastard.

BILLINGS' ESTIMATE OF QUANTITY.

A remarkable paper bearing on the quantity of ore in some of the foregoing mines and properties appeared in the second volume of The Canadian Naturalist and Geologist by Mr. E. Billings, a gentleman who was for many years connected with the Geological Survey. Referring to the Hull mine on the Ottawa river, he described it as one hundred feet in thickness, instead of twenty feet as had been supposed by Sir William Logan, and stated upon the authority of Dr. Hunt that it contained about 70 per cent. of pure iron. The limits of the mine had not at that time been traced, but Mr. Billings had no doubt that this bed underlies the country for many miles in one continuous sheet. "It is not a vein filling up a perpendicular fissure in the earth's crust, but a bed lying between the strata of the formation. Where it is exposed it forms a dome and dips away in all directions. How far it extends cannot be ascertained, but granting that 500 fathoms is its limit each way, then it would contain 250,000,000 of tons of pure iron." This mine is situated five miles from the city of Ottawa, on the Quebec side of the river. Of the Crosby mine on the Rideau canal Mr. Billings said: "This bed is said to be nearly 200 feet thick, and should its yield be as great in proportion as that of the Hull mine, it would contain in a superficial area of 1,000 fathoms 500,000,000 of tons of pure iron. This enormous bulk of metal can scarcely be conprehended. Were the whole iron mining force of Great Britain and the United States at work for one hundred years upon such a deposit, they would not, at their present rate of production, exhaust it." Then as to the deposit in South Sherbrooke, he described it as a bed 60 feet in thickness, and estimated its probable contents at 100,000,000 tons of pure iron. Of the specular iron ore location in the township of McNab, he said: "The bed is twenty-five feet thick, and contains perhaps 50,000,000 of tons to the 1,000 fathoms square. It is situated about one mile from the village of Arnprior, thirty miles from the city of Ottawa, and in the midst of an abundance of water power." After noting that the beds from which the Marmora iron works were at that time supplied might be estimated as containing 100,000,000 tons, Mr. Billings proceeded to say: "We have therefore in the above five beds in round numbers 1,000,000,000 of tons—a quantity sufficient to yield 1,000 tons of iron a day for 3,000 years, could furnaces be erected and kept in operation capable of smelting that quantity. And as the deposits above-mentioned are only a part of the known iron wealth of the Province, and in all probability but a small proportion of that which is at present unknown, but must be brought to light as the Laurentian region becomes settled, it is clear that we may safely consider the stores of this metal inexhaustible."[11] Mr. Billings spoke with the

Estimates of iron in ore beds of the Ottawa valley and eastern Ontario.

Hull mine.

Crosby mine.

South Sherbrooke and McNab beds.

Marmora ores.

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[9] Geological Survey of Canada, 1858, pp. 47-8.

[10] Geological Survey of Canada, 1851-2, pp. 82 and 105.

[11] The Canadian Naturalist and Geologist, vol. II. first series, pp. 23-4.

authority of an old officer of the Survey, and although his fame rests upon studies made in another department of the work of the Survey, viz., palæontology, it cannot be supposed that he made such explicit reference to the possible supply of ore in the localities mentioned without careful examination and inquiry. Yet in view of the pitiful results of mining operations at Hull and South Crosby, it may well be questioned if in respect to his estimates of quantity, description of quality and claim for economy of working, there is not an air of extravagance. One can hardly credit the possibility of the existence of the equivalent of 500,000,000 tons of pure iron on the line of the Rideau canal, which could be mined, loaded upon canal boats, delivered at Kingston and transferred to lake vessels for Cleveland or Oswego at $2.25 per ton, when iron ore was selling for $6 per ton at Pittsburgh, and yet such a mine to lapse into idleness. Even at present prices and in the face of a duty of 75 cents per ton, its working ought to yield a good margin of profit. I am not aware that Mr. Billings' estimates of the quantities of ore in these localities have ever been disputed. But we shall see farther on why the Chaffey mine failed to realize expectations.

THE HASTINGS AND FRONTENAC DISTRICTS.

The existence of iron ore in the districts north of Kingston, Belleville and Cobourg was known at an early period in the history of the country, and we have seen that as long ago as 1823 a blast furnace was erected in the township of Marmora to smelt ores taken from the Big Ore bed at Blairton. Frequent references to the occurrence of magnetic iron ores in those localities are made in the early reports of the Geological Survey, yet it was not until 1852 that the region was visited by an officer of the Survey. In that year Mr. Alexander Murray explored the country lying between the township of Bedford in Frontenac and the river Severn; the object being, as stated by Sir William Logan, to trace the general outcrop of the lower fossiliferous rocks along the more mountainous metamorphic group which comes from beneath them on the north, and to ascertain the nature of the economic materials associated with both at moderate distances from their junction. The following account of the occurrence of magnetic and specular iron ores in the region traversed by him is taken from Mr. Murray's report:

Report on the magnetic and specular ores of the region by Murray.

"Ores of iron are very generally disseminated through the rocks of the Laurentian group, and when existing in large workable masses appear to be usually either in contact with or at no great distance from the crystalline limestones. The localities where the magnetic oxide was chiefly met with were in Bedford, Madoc, Marmora, Belmont and Seymour; and although the information received by me from time to time makes it appear probable there must be many more places where it abounds, I did not see except in these townships any instance where the material was in sufficient quantity to warrant the experiment of working it. One of the localities visited was on the 21st lot of the ninth concession of Bedford, where the magnetic oxide occurs at the foot of a ridge of gneiss, associated with a greenish rock consisting of an aggregate of greenish felspar, and numerous large prismatic crystals of greenish hornblende in a pale fawn-colored calcareous base. The bed to which it belongs is not well exposed as it lies in a hollow, the greater portion of which at the time I was there was covered with growing grain; but its presence was indicated in the same position and associated with the same minerals by the fragments strewed upon the surface for about a quarter of a mile in a northeast direction from where it was first seen. To the westward there is a fault running north 25° west and south 25° east which throws the ridge of gneiss about 150 yards to the southeastward on the southwestward side; but although a careful search was made for the continuation of the ore, both in the direction of the dislocation and on the southwestward continuation of the ridge, it was nowhere found. The bed of ore did not appear to be over three

In Bedford.

or four feet thick. Immediately on the southeast of the ridge crystalline limestone comes in with its associated beds, dipping on the average northwest at an angle of 30°. Another exhibition of the ore occurs in Bedford, near the northeast end of Bob's lake, supposed to be in the twenty-fifth lot of the fifth concession. It was found in small fragments near the foot of a ridge of crystalline limestone, but nowhere in place, and is probably of no economic importance.[12]

In Olden.

"I was informed by an Indian that iron ore had been found a little way to the north of the portage, about half way between a place called the Beaver Dam and Cross lake in Olden, but although a whole day was expended in the search it was nowhere found, except in small specks or crystals in the felspathic rock of the country.

In Madoc, Marmora and Belmont.

"The deposits of iron ore in Madoc, Marmora and Belmont, some of which have long been known and have been worked will probably hereafter become of great commercial importance. The ore, which was formerly smelted at the village of Madoc by Messrs. Seymour & Co., and produced an excellent quality of iron, was mined on the eleventh lot of the fifth concession of the township. The bed appears to run through a black, soft, micaceous rock, and holds a course which, as far as it was traced, was about west by north and east by south, while the slope of the bed, which is towards the south, was between seventy-five and eighty degrees. The greatest observed breadth of the bed appeared to be about thirty feet, and its average would probably not fall short of about twenty feet. A material similar to the soft, black, micaceous rock, which accompanies the bed of ore on each side, appears every now and then to cut it diagonally in thin belts. In one place the bed is said to have been thus cut at distances of from every three to ten feet, and in another there was an unbroken part with a length of fifty feet. The ore is very black and very fine-grained, and while the whole body of it is magnetic, some portions of it have polarity, one end of a fragment repelling and the other attracting the north end of the magnet. When the ore is bruised with a hammer on these portions of the bed, or on fragments taken from them, the particles adhere to one another and stand up on the mass as they would on a magnet, the ore being, in short, a natural magnet or loadstone. The portions which have polarity appear to run across the ore-bed at right angles. Nodules of actinolite or green fibrous pyroxene, made up of radiating crystals, are disseminated in the ore, and yellow uranite is found investing small cracks. I was informed that in the general direction of the bed traces of ore have been met with twice to the eastward, in the tenth lot of the sixth and the ninth lot of the seventh concession, and to the westward in the twelfth lot of the fourth concession, the distance between the extreme points being about two miles.

Loadstone.

Big Ore bed, or Blairton mine, in Belmont.

"On the eighth lot of the first concession of Belmont is situated the bed of magnetic oxide which yields the ore formerly smelted at the Marmora iron works. It is commonly known as the Big Ore bed, and has usually been called a hundred feet thick; it appears however not to be a single bed, but a succession of them, interstratified with layers of greenish talcose slate and crystalline limestone, occupying a breadth across the strike and back from Crow lake, into which it obliquely runs, of about eight chains. The general strike of the strata appears to be about south 40° east, and the slope towards the northeastward from 25° to 50°. At one place, on a surface of greenish colored mica slates, underlying coarse disintegrating crystalline limestone, the dip was north 62° east at an angle of 50°; but surrounded by the strong magnetic attraction of the ore bed, the compass could not be relied on as giving a true bearing. Crystalline limestone overlies the mass, and the first hundred feet of the metalliferous strata show a vast bulk of ore, the upper portion of which chiefly was mined for smelting. Of the lower part, thirteen feet towards the bottom were also mined, but not to the same extent. Associated with the ore and the talcose slates accompanying it, diallage rock and serpentine occur, and a pale green rock, translucent on the edges, and harder than serpentine, deriving its character from the presence of pistachio green epidote; through this green rock the ore is usually very thickly disseminated. The upper metalliferous beds suffer in quality from the presence of iron pyrites, from which the lower beds appear to be wholly free, thus yielding a much finer quality of ore. This part of the mass was not resorted to while the smelting works were in operation, until a short time before they were abandoned; but when the ore from it was used the daily yield of iron, I am informed, was increased in the ordinary process of smelting from three and a half up to four and a half and five tons.[13]

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[12] "On the twenty-first lot of the ninth range of Bedford a bed of magnetic iron ore three or four feet in thickness occurs at or near the junction of the gneiss with the crystalline limestone. Deposits of this ore are also said to have been recently discovered on the sixth lot of the third range, and on Black lake in the eighth lot of the fourth range of the same township; but no details are yet known with regard to them." Geology of Canada, 1863, p. 674.

Ore deposit north of Crow lake.

"On the north side of Crow lake, about 300 yards from the shore, on the twelfth lot of the third concession of Marmora, magnetic oxide of iron occurs, thickly but irregularly disseminated in a pale green epidotic rock, similar to some portions of the rock of the Big Ore bed. At the time the Marmora works were last in operation an opening was made at this place which shows a breadth of twenty to thirty feet, all of which contains the ore, sometimes distributed in patches in the direction of the stratification, and sometimes in large irregularly shaped lumps and solid masses. The bed runs nearly east and west, apparently dipping south, and was readily traced for about 300 yards to a clearing, where it terminates in a sharp cliff. Such of the ore as was used at the works is represented to have proved of excellent quality, and to have added considerably to the daily yield of smelted metal; it seems to be peculiarly free from pyrites. The rock along the north shore of Crow lake is frequently of the pale green color and epidotic character which marks this ore bed, and has grains of magnetic iron diffused through the mass, from which circumstance it appears probable that the ore-bearing portion is continuous, although it may not in all places be equally productive. The course of this ore westward would at length carry it to an intersection or junction with the northwestward course of the Big Ore bed; and the dip of the one bed being south and the other northeast, it seems probable that they may prove to be different parts of the same bed on the opposite sides of a synclinal form.[14]

In Seymour.

"At Allan's mills, on the twenty-fifth lot of the twelfth concession of Seymour, where the dome of Laurentian rock protrudes through the fossiliferous limestone, magnetic iron ore is thickly disseminated in the rock over all the area exposed, which is about two or three acres. The rock on the left bank of the river appears to be a conglomerate of the Laurentian series, in which the presence of rounded forms supposed to be pebbles is perceptible on the smooth polished surfaces, where they display various colors; but these pebbles, when the mass is broken across, are so intimately blended with the matrix as to seem almost perfectly homogeneous with it; the iron ore in the conglomerate is disseminated only in small crystals and thin strings at wide intervals, but the succeeding rock, which seems to overlie it (the dip being to the southeast), and is a strong and tough mixture of whitish felspar with dark green pyroxene, yellowish-green epidote and occasional patches of red felspar, holds magnetic iron ore in considerable quantity. The breadth of the ore-bearing portion is at least thirty yards, and the run seems to be nearly parallel with the river; but although the distribution of the ore is pretty general, it scarcely appears to be in sufficient abundance, so far as may be judged from surface specimens, to be worked with advantage.

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[13] "Many years ago a blast furnace was erected at the village of Marmora for the purpose of smelting the ore from this deposit, and iron of a superior quality was manufactured. More recently different companies have for short periods made renewed attempts to smelt the ore with very satisfactory results so far as the quality of the metal was concerned. The distance of the place from a shipping port was however found a serious obstacle to success, and the furnace is for the present abandoned." Geology of Canada, 1863, p. 676. See also pp. 14-22 of this Report.

[14] "An opening which has been made here exposes a breadth of from twenty to thirty feet, through which the ore is irregularly disseminated in lumps and masses running with the stratification, which is nearly east and west, and apparently with a southward dip. The bed was traced for about 300 yards to a clearing, where it terminates in a sharp cliff." Geology of Canada, 1863, p. 675.

Indications of hematite and specular ores.

"There are other places in Marmora and the adjoining townships where iron ore has been found, and some that have been partially worked, one of which was on the ninth lot of the eighth concession of Marmora, in which a fine-grained hematite in patches constitutes the ore. Near the ore-bed are large loose masses of rock with dark red garnets in cavities or druses associated with pyroxene and calcspar. Specular oxide of iron is known to exist at some place near the Deer river, north of Belmont lake. I procured a few specimens of it from a person who had been diligently working the ore under the delusion that it contained from forty to sixty per cent. of silver. What the character of the vein or bed in which it occurs may be it is not in my power to say, as I did not succeed in finding the place, nor could I get any satisfactory account from those who had visited it. In almost all parts visited this year, but more especially in the back settlements, a great number of the inhabitants are possessed with the delusive belief that the precious metals abound among the rocky ridges of the Laurentian country, and that they by their own individual exertions are capable of realizing vast wealth. Iron pyrites, mica, plumbago, specular iron, galena and other bright or metallic substances are indiscriminately collected, barrelled and buried in the woods, with the full impression by those engaged in such business that they have stored away so much gold and silver; and although every second person met with had a specimen of some sort to present, with anxious enquiries as to its nature, hardly a single individual could be found who was willing to give the smallest information as to its locality. It was in vain to argue with such persons that the consequences of a proper examination might possibly be more advantageous to the common interest than anything they were likely to accomplish in secret and unassisted; such an argument was only regarded as the result of a governmental scheme to deprive them of their imagined wealth; and an appearance of anxiety to procure information only rendered their secrecy the more profound.

Delusive beliefs of the possession of mineral wealth.

"The specular oxide of iron was seen during the season's examination in a few places, but in no one instance in anything like sufficient quantity to be of any economical importance."[15]

MACFARLANE'S REPORT ON THE HASTINGS DISTRICT.

A second report on the geology of the Hastings district was made by Thomas Macfarlane in 1865, when several locations reported upon by Mr. Murray were again examined, together with some others not previously known. Among the beds of magnetic iron ore which Mr. Macfarlane found to occur in large or apparently remunerative quantity are those on the following locations: Lot 3 in range 5 of Elzevir, 19 in 1, 11, 12 and 17 in 5, and 25 in 6 of Madoc, 13 in 3 and 6 in 9 of Marmora, and 7 and 8 in 1 of Belmont.

The Seymour bed.

Referring to the Seymour bed, Mr. Macfarlane says the strike of the ore is almost at right angles with the rock of the neighborhood, which perhaps is owing to the proximity of the granite. The overlying rock is chlorite slate, and chlorite also occurs intermixed with the ore. A great part of the ore is solid and free alike from rock and pyritous impurities. The same bed is supposed to continue through lots 9 and 10 in the sixth range, 8 in the seventh and eighth and 12 in the fourth, but no deposits of importance were found on these lots.

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[15] Geological Survey of Canada, 1852-3, pp 137-42.

On lot 19 in the first range of the same township a partially exposed bed was observed which had an apparent thickness of twenty-five feet, but it could not be accurately measured. The compass was found to be quite useless near it, varying very greatly from a due north line on approaching the deposit and as much as 90 degrees when immediately over it. The ore was stated to be in great part pure and solid, but some of it contained iron pyrites.

A cause of failure in smelting ore of the Big Ore bed.

Referring to the Big Ore bed of Belmont, Mr. Macfarlane observed that a very considerable part of the difficulty experienced in treating the ore from this mine at the Marmora furnaces must be attributed to the fact that no attempt was made at sorting it, in consequence of which it contained too large a proportion of pyrites. "The substance which principally forms the matrix of the ore is a pyroxenic greenstone, the nature of which was not all taken into consideration in the metallurgical treatment of the ore. It doubtless contained comparatively little silica, and required probably little or no limestone to flux it. On the other hand, its poverty in alumina would render the addition of clay or lime of much advantage in its treatment in the furnace." There were two principal openings at this mine about 250 feet apart, the dip in the most northerly, which is the principal one geologically, being 60° north-eastward, and in the other 80°.

The Marsh bed in Marmora.

The bed on lot 6 in the ninth range of Marmora, known as the Marsh ore bed, has the same strike as that of the Big Ore bed, namely, northwest and southeast, and the dip is 50° northeastward. Much of the ore was found to be pure and solid, but a large quantity of it was contaminated with iron and copper pyrites.

Hematite.

Several beds of hematite ore were also reported upon by Mr. Macfarlane as occurring in the townships of Madoc, Elzevir and Marmora, but none of them in large quantity.[16]

ARCHÆAN ROCKS OF EASTERN ONTARIO.

Mr. Vennor's reports on the region from Marmora lake to the Ottawa river.

The first detailed examination of the Archæan rocks in the eastern part of the Povince, and the economic minerals which they contain, was begun by Mr. Vennor in 1866 under the direction of Sir William Logan, and was continued for a period of ten years. The territory surveyed by Mr. Vennor extends in an easterly direction from Marmora lake through Hastings, Addington and Frontenac to the Rideau waters in the northwestern corner of Leeds, and thence northerly through Lanark and parts of Renfrew to Allumett island in the Ottawa river. The rocks lie in a series of troughs running with the course of the belt, and from the various reports made upon them it is apparent that their geological relations are not easily understood. In the earlier reports they were described as belonging to the Laurentian system. Mr. Vennor at first was disposed to classify them as Laurentian and Huronian, and subsequently as a new series to which the name Hastings was given. Other classifications of rocks were also made in the course of his work, especially in the county of Lanark; but in the final report, reviewing the whole field of exploration, the general conclusion arrived at was that they consisted of two divisions, the lower composed of gneiss and syenite and the upper of gneisses and crystalline limestones. The latter he described as occurring altogether upon the southern side of the belt, and dipping under the lower Silurian formations which cover the country southward to the St. Lawrence. Mr. Vennor was also of opinion, from his first year's observations in Hastings, that the magnetic iron ores were included in hornblendic and pyroxenic rocks which constituted the second of the three divisions into which the formations of Hastings and Addington were grouped; but examinations upon other parts of the field proved that this conclusion was not tenable. It follows therefore that the theory interwoven into the first extract which follows is not to be entertained. It may be indeed that the occurrence and origin of iron ores in this district must be studied anew before a theory can be adopted which would possess practical value for the explorer and the miner. Mr. Eugene Coste, who spent the seasons of 1884-5 in Hastings and the adjoining counties north and west of it, arrived at the conclusion (at variance with the views of Logan, Hunt, Harrington and Vennor) that both the iron ores and the apatite found in the Archæan rocks are of igneous or eruptive origin, which is important if true. But his report and geological map have not yet been issued, although their early publication was promised several years ago.[17]

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[16] Geological Survey of Canada, 1863-6, pp. 97, 103.

In the report of 1866-9, after three years of work in the Hastings and Addington field, Mr. Vennor thus describes the occurrence of iron ores in the townships of Madoc, Marmora and Belmont—his three divisions of rocks, A, B and C, being premised:

Iron ores in Madoc, Marmora and Belmont.

The ores in a continuous horizon.

"The deposits of iron ore in Madoc, Marmora and Belmont, which occur in the ferriferous band at the base of the greenish hornblendic and pyroxenic rocks, have been alluded to in several of the early annual reports of the survey; they have also been noticed in the General Report on the Geology of Canada for 1863, pp. 675 and 676, and again in greater detail in Mr Macfarlane's report for 1866. In these various reports however they have been described as separate local deposits, a sufficient number of facts not having then been accumulated to unite them in one continuous horizon. But having during the last three seasons, in accordance with your instructions, examined them more in detail with relation to the rocks in which they are enclosed, I have been able to satisfy myself that, with one or two unimportant exceptions, nearly all the deposits of magnetic oxide in the district will be found in the present division [B], being sometimes its only representative. As the deposits of irom ore already known in this zone are of economic importance, and as other yet undiscovered masses of a similar character may exist, I shall, with a view of aiding the search for them, here give a somewhat minute description of the course in which it appears to me they will be found to run.

A belt of ore traced from the Seymour bed to the Big Ore bed.

"The Seymour ore bed is situated on the eleventh lot of the fifth range of Madoc, where the associated hornblendic and pyroxenic rocks, and certain chloritic slates there occuring, are well displayed. Their course from this lot is about S. 65° E. (mag.), and passing through the tenth and ninth lots of the sixth range, and the eighth and seventh of the seventh range, along which course the ore is almost continuous, it becomes partially covered up by the unconformable Lower Silurian limestone; but turning over the axis of an anticlinal it can be traced curving through the seventh, eighth and ninth lots, and part of the tenth in the eighth range, whence it strikes N. 65°-70° W. (mag.) through the tenth, eleventh and twelfth of the seventh range, and thence through the thirteenth, fourteenth and fifteenth of the fifth range. On the last named lot a deposit of magnetic ore occurs perhaps next in importance only to the Seymour bed, and it is worthy of note that its place here is exactly opposite to this bed and on the other side of the anticlinal mentioned, on the crown of which occurs a coarse red syenitic rock, (A 1) which has been before referred to. From the seventeenth lot of the fifth range the course of the iron-bearing rocks gradually tends westerly, and would appear to pass through the seventeenth and eighteenth lots of the fourth range, the eighteenth of the third and the eighteenth and nineteenth of the second and first ranges.

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[17] I learn from Dr. Selwyn that the delay has occurred through failure of Mr. Coste to furnish his report on the district. The map was printed several years ago, "but it has been reserved, daily expecting the report which ought to accompany it."

On these last named lots in the first range the ore is probably again in considerable quantity, but the traces of it occur only in loose masses in the soil, the ore in place being apparently at a considerable depth beneath the surface. From these lots the band runs into the township of Marmora, and, changing its direction, trends southward, keeping almost immediately to the east of the Moira river, the course of which might almost be said to denote its further run through this township. On the nineteenth and eighteenth lots of the eleventh range this iron zone is represented by rust-stained slates, holding some considerable beds of yellow sulphuret of iron with traces of magnetic iron ore, and here it is closely associated with a large mass of coarse white granular limestone. Thence it runs southward through the tenth, ninth and eighth lots of the ninth range, where the McCallum iron ore bed, mentioned in an early report, is situated; while farther southward its course is indicated on the sixth and seventh lots of the eighth range, by the occurrence of the Marsh ore bed. A short distance beyond these last lots the ferriferous belt must run under the main body of the Silurian limestone lying to the south and to the east, where it is lost sight of. But while thus covered it appears to change its course, and bearing westward emerges at Marmora village, where the green hornblendic and epidotic rocks are marked by traces of magnetic iron ore, and hold veins of red hematite. These rocks are seen running into Crow lake, under the waters of which, and under the adjoining unconformable overlying horizontal lower Silurian limestones, the greater part of the strata of this division are concealed. The north shore of the lake however gives evidence of the course of the belt in the Kean ore bed, which occurs on the thirteenth lot of the third range of Marmora, and in an exposure protruding through the Silurian limestone on the sixth lot of the first range of this township. The Big Ore bed, on the south shore and western extremity of the lake, in Belmont, belongs to the same belt, and is probably brought up on a third line of elevation to the westward.

"Northeastward through Belmont no very large exposures of the ore have yet been observed; but deposits may still be found between Crow and Belmont lakes, along the western shore of the latter, and up the valley of the Crow river, as well as on Deer lake, about the twenty-fifth, the twenty-sixth and twenty-seventh lots of the second and third ranges. The exposure at Allan's Mills, on the twenty-fifth lot of the twelfth concession of Seymour, noted by Mr. Murray in his report for 1852-53, has probably some relation to the turn which occurs in the course of the belt in Belmont lake, but whether united by a continuous outcrop, or separated on the opposite side of an anticlinal form, the overlying Silurian limestone prevents us from deciding.

Tracing the belt eastward from Seymour bed.

"Returning to the Seymour bed in Madoc, with the view of tracing this belt eastward, we find very few deposits of the ore of any extent. On the twelfth lot of the fourth range we have a small bed of magnetic iron ore, and again on the sixth lot of the third range, beyond which, southward, the belt runs under the Silurian. At the eastern end of Hog lake, on the Moira river at Downey's rapids, magnetic iron ore is again met with, and finally in Elzevir, on the third lot in the fifth concession, where it occurs in a bed from two to three feet thick enclosed in a steatitic material, as mentioned by Mr. Macfarlane in the report of 1866.

"Where the rocks of division B are brought up in the northwest quarter of Madoc magnetic iron ore has been found on the twenty-fifth lot of the sixth range of Madoc, where a small bed occurs dipping to the northeast at an angle of from forty to forty-five degrees. The only other locality is in the extension of the belt farther north, on the fifty-fifth lot on the west side of the Hastings road in Tudor, where it is associated with gneiss and granular limestone (A3 and A4). This last locality has not been mentioned in any of the previous published annual reports, but samples of the ore were sent by

A belt from Madoc northward into Tudor.

you to the London Industrial Exhibition of 1862. The ore would appear to be of excellent quality, although more or less mixed with graphite. The breadth of this bed could not be determined, owing to the wood-covered condition of the country, but from the large masses of ore scattered about in the vicinity there is little doubt that it occurs in abundance.

"It is probable that other beds of this ore will yet be found along the course of the rocks B, whose distribution has thus far been partially pointed out, and will be further understood from the description to be given of the next overlying division C, at the base of which this ferriferous belt occurs."

Working the Big Ore or Blairton mine.

Referring subsequently to the Belmont ore bed, Mr. Vennor states that in 1857 an American company was established for the purpose of working the property, and that after trials of several parts of the band the portion near the base was found to be of suitable purity for smelting. Three hundred men were employed in mining and sorting the ore that year, and towards the end of the season one hundred and fifty tons a day were carried by rail to Cobourg and there shipped to the American side where it was smelted at Pittsburgh. A few hundred yards southeast from the main work another excavation was made on what was called the Sandpit bed, from which a very pure ore was obtained. The ores raised from both mines were sorted into three grades, the two highest of which were selected for exportation, while the third was left on the ground for future disposal.[18]

Survey of Addington and Frontenac: classification of rocks.

In 1870 Mr. Vennor continued his survey eastward through portions of Addington and Frontenac, and while still classifying the rocks under the three divisions already referred to, he was able to summarise them briefly as follows, in ascending order:

A. Gneiss, fine, syenitic, with crystalline limestones and magnetic iron ores (Laurentian);

B. Diorites and diabases, passing into chlorite schists, often epidotic with steatite, and with magnetic and hematitic iron ores (probably Huronian);

C. Dolomites, argillaceous, calcareous and micaceous schists, with gneisses.

Here it will be observed that iron ores are found to occur in the first division, differing in this respect from the occurrence of those ores in the Hastings district, and indeed Mr. Vennor states that the second division afforded no iron ores in the region examined during the season of 1870; they were found closely associated with the limestones division.

Tracing a belt from Howse mine in Bedford to North Crosby, fifteen miles.

Besides other localities previously referred to, in which ores were found in the township of Bedford, was one known as the Howse iron mine on lot 4 in the first concession, where a bed of solid magnetic ore had been uncovered for about twenty-five yards across the strike. Fifty tons was raised from this mine in 1869 for shipment to Charlotte, N.Y., and the ore was found of good quality. In the following year 100 tons was mined and drawn to Westport on the Rideau. Northeastward of the Howse bed magnetic ore was again found on lot 6 in the third and lot 8 in the fourth concession of the same township. These localities are referred to by Sir William Logan in the report for 1858,[19] where it was conjectured that they would be found to continue to one on lot 21 in the ninth concession noted by Mr. Murray in his report for 1852-3. This supposition Mr. Vennor was enabled to verify having traced a zone of the iron-bearing rock from the Howse mine to lots 20 and 21 in the ninth concession of Bedford and thence northeastward to lot 19 in the eight concession of North Crosby at Spectacle lake, a distance of fifteen miles.

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[18] Geological Survey of Canada, 1866-9, pp. 150-2 and 161. Dr. Sterry Hunt in the same report, p. 258, states that much of the ore shipped from this mine to Pittsburg was found to be objectionable on account of the considerable proportion of sulphur which it contained, but that the Sand-pit bed yielded a much purer ore. Mr. J. L. Aunger of Blairton has sent me the following note under date of December 8 concerning the present condition of Blairton mine: "It is the most strange thing I know to see this mine, with its half-million tons or more of iron ore within three miles of the Canadian Pacific Railway lying idle, and parties passing it by going 40 miles or more from a railway looking for iron ore. If the same body of iron could be placed 40 miles in the woods where attention is given to seeking for minerals it would take well, and the first thing would be, 'Now then, for a railway to it.' I know what I am writing as to the quantity of ore in this mine, and don't fear to meet it in print."

[19] See p. 35 ante.

Allan's mine in North Crosby; the belt traced through South Sherbrooke and Bathurst.

A deposit of magnetic ore on lot 27 of the fourth concession of North Crosby seemed to Mr. Vennor to be a most valuable one, and it would appear to form the first of another series of similar deposits stretching northeastwardly through South Sherbrooke and Bathurst. The ore is a fine crystalline magnetite, and the openings showed the existence of a large amount. Explorations of the property were made in 1868 under direction of the owner, Hon. George W. Allan, and about 100 tons of ore was raised, but the untimely death of the miner in charge caused the work to be discontinued.[20]

Fournier and Bygrove mines, and other occurrences in Crosby and Bathurst.

On lot 14 of the first concession of North Crosby there is apparently a bed or belt of magnetic ore parallel to Mr. Allan's deposit, known as the Fournier mine, and on lot 3 of the same concession is the Bygrove mine. The latter had been opened during 1869 by Mr. George Oliver of Perth, who mined about 150 tons of a very fair quality of magnetic ore. Other occurrences of iron ores were found on lots 17, 18 and 19 in the third concession of this township bordering on Christie's lake, and again on the 10th and 11th lots in the eighth concession of Bathurst, which had been worked to some extent by a Perth company. On the last mentioned lots the magnetic ore was found to be much mixed with a fine crystalline green apatite.

The Dalhousie mine.

On the east half of lot 1 in the fourth concession of Dalhousie a valuable deposit of hematite ore was opened in 1866 and was worked for several years. The bed is described by Mr. Vennor as averaging seven feet in width in a band of crystalline limestone, and dipping at an angle of 45° to the southeastward. Six shafts of eight by ten feet and varying from 20 to 68 feet in depth had been sunk by November, 1871, and about 10,000 tons of ore was raised. The ore was drawn to Perth, a distance of twelve miles, in summer at $1.75 per long ton, and in winter at $1; from there it was taken by rail to Brockville and thence shipped to Cleveland, where it was laid down at a cost of $5 per ton. The ore was claimed to average 60 per cent. of iron, according to numerous analyses made in the United States, but six determinations in Canada afforded an average of 57 per cent., with about .025 phosphorus.[21]

Shipments from the Chaffey and Yankee mines.

In a note upon the Chaffey mine in South Crosby to which reference has already been made, Mr. Vennor found in 1871 that two excavations had been made to a depth of thirty feet in a solid bed of magnetic iron ore, and during that year, with twelve men employed, 3,500 tons of ore was raised and shipped to Cleveland via Kingston. At the mine this was worth $2.25 per ton, and delivered at Cleveland it brought from $6 to $6.50 per ton. The cost of carriage to Kingston, a distance of 44 miles over the Rideau canal, was 75 cents per ton. About one hundred rods north-northeast from the Chaffey mine, and on a continuation of the same bed, is the Yankee or Matthews mine, upon which work was commenced in 1860. The opening made here had a depth of 40 feet in 1871, during which year fifteen men were employed, 4,000 tons of ore was mined, and 3,300 tons sold and shipped to Cleveland, where the price obtained was the same as for ore of the Chaffey mine. The total amount of ore sold and shipped to Cleveland from these two mines for the two years 1870 and 1871 amounted to 14,520 tons.

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[20] In a letter received from Senator Allan that gentleman says: "Unfortunately the person I employed, a Mr. Otey, was taken suddenly ill and died without making any full report as to the nature and extent of the deposit. Since then I have not taken any steps to have the property further developed. Iron mining except in a few places had gone down. My property labored under the disadvantage of being five miles from water communication at Newport, and at that time there was no railway passing near it, and so I have allowed it to remain, being satisfied that whenever iron mining revived and was carried on extensively my property would come into play." In the Report of 1866-9 Sterry Hunt gave an analysis of the ore, showing it to contain 64.9 metallic iron, 1.03 titanic acid, 1.33 alumina, .82 lime, .84 magnesia, .007 phosphorus, .120 sulphur, traces of oxide of manganese, and 5.25 insoluble matter, chiefly quartz, with a little black mica and green pyroxene. Dr. Hunt says: "This is a very fine and valuable ore, and the deposit would seem to be worthy of careful examination."

[21] Geological Survey of Canada 1870-1, pp. 312-4; also do. 1871-2, p. 122. "The production from February, 1872, to the end of February, 1873, was forwarded to Perth at $1 per ton, in loads which averaged three and three-quarter tons; thence to the Rideau canal at 60 cents; thence to Kingston at $1.25 to $1.50, and thence to Cleveland at from $1 to $1.50. The total production from 1870 to 1873 has been rather over 11,100 tons. The wages of the hands employed have varied from 80 to 90 cents. per day, with board."—Vennor's Report for 1872-3, p. 177.

Referring to the quality of ores from these and other mines in the locality, Mr. Vennor made the following notes in his report:

Quality of iron ores in the district.

"Samples of ore from the Chaffey, Yankee, Bygrove, Fournier and Foley mines were, in accordance with your instructions, submitted to Dr. B. J. Harrington for analysis. The following figures show his determination of the percentage of metallic iron in these ores, but more time will be required for their complete examination:

Chaffey mine	52.91	per cent. metallic iron.
Yankee mine	52.09	" "
Bygrove mine	59.55	" "
Fournier mine	59.59	" "
Foley mine	58.69	" "

Titaniferous ores.

"The ores from the Chaffey, Yankee and Foley mines were all found to be titaniferous. That of the Chaffey mine is stated by Dr. Hunt to contain 9.80 per cent. of titanic acid. Dr. Harrington finds 12.32 per cent. of titanic acid in the ore from the Yankee mine, and also a large amount of sulphur, which renders it altogether an inferior ore. The ore from the Foley mine contains only 2.68 per cent. of titanic acid, which is not a sufficient amount to detract from its value. The Chaffey and Yankee ores were also examined for phosphorus, but neither of them was found to contain a weighable amount. The Bygrove and Fournier ores are free from titanium, and I think it extremely probable that they will be found to belong to beds somewhat higher in the series than the titaniferous ores."[22]

Iron ores found in association with crystalline limestone bands.

Other explorations in this region during the season of 1872 appear to have convinced Mr. Vennor that the iron ores were only to be found in connection with crystalline limestones. Magnetic iron ore was reported to exist in the gneiss area of Frontenac, in the townships of Kennebec, Clarendon and Palmerston, but Mr. Vennor found them only in grains or in connection with dykes, and nowhere in sufficient quantity to be of economic importance. The entire absence of crystalline limestones in this section he mentioned as a fact worthy of note, and although it might be premature to say positively that all the available deposits of magnetic or other ores of iron occur and are to be sought for in proximity to such limestones, still the accumulation of evidence over a great extent of country examined would appear to point in this direction.[23]

During the season therefore the bands of crystalline limestone were by him made a special object of investigation; first, because they presented characters which enabled them to be much more easily followed than any of the intervening gneiss bands; and, secondly, because that with them, or in close proximity to them, are deposits of iron ore and apatite in economic quantities. Cross sections of the country were made through the townships of Oso, Olden and Bedford, as well as through South Sherbrooke, in which six distinct bands of limestone were observed having a southeastward dip varying from 28° to 60° and running for the most part in east and west lines, but after being traced a distance of 20 or 25 miles eastward they were

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[22] Geological Survey of Canada, 1871-2, p. 123.

[23] Geological Survey of Canada, 1872-3, p. 149.

Magnetic ore in the higher limestone bands.

found to curve in a northeasterly direction; and in relation to these bands of limestone the attempt was made to assign the geological horizon of the iron ores. The occurrence of ores, Mr. Vennor observes, appears on lines which bear a certain relation to the occurrence of some of the bands of limestone and form distinct horizons which can be followed and in which other deposits of iron may be sought for. Immediately above the sixth and highest of those bands magnetic iron ore occurs in South Sherbrooke in two places, viz., at the Bygrove mine on the third lot of the first concession, and at the Fournier mine on the fourteenth of the same range, as well as in other places on the same horizon to the eastward through Bathurst and to the southwestward through Bedford. At the base of the fifth band ore occurs along the northern shore of Christie's lake in the same township, in the eighteenth, nineteenth and twentieth lots of the third concession, at what was then known as the Watson mine. Immediately below the fourth band ore was found at the Foley mine on the tenth lot of the eighth concession of Bathurst, whence it could be traced through the eleventh, twelfth and fourteenth lots of the same concession. Here for the first time apatite was found in considerable deposits closely associated and in some instances intermixed with the iron ore. In the third, second and first bands of limestone no magnetic ore had been met with by Mr. Vennor, although at the base of each of these rust-colored strata occur; yet he observes as worthy of note that the great bed of hematite in Dalhousie township upon which is situated the Dalhousie mine is found between the first and second limestone bands, and the general conclusion is thus stated: "From the foregoing it will be seen that in the section of country so far examined by me magnetic iron ore has been found only in connection with the three highest bands of limestone, while in the other bands it is represented by only rust-colored beds of gneiss and quartzite."[24]

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[24] Geological Survey of Canada, 1872-3, pp. 159-162. In the report for 1873-4 Mr. Vennor appears to have doubted the occurrence of the sixth band of limestone. Of the fourth and fifth he gives the following description, pp. 105-6:

"The Crow lake, Rock lake and Silver lake band of limestone is well marked and important. It is separated from the last by a great volume of granitic gneiss, which is probably not less than eight to nine thousand feet thick. From Eagle lake, in the northeastern corner of the township of Hinchinbrooke, it has been traced to the head of Crow lake, in Oso; thence northeastward to Rock lake, a small lake situated close to the townline of South Sherbrooke. Entering this last township, it runs through portions of the fifth and sixth concessions, passing a little to the north of Silver lake, and enters the sixth concession of Bathurst, whence, again trending northeastwardly, it passes through the seventh concession to the eighth concession line, which it follows, in a nearly direct course, to Balderson's Corners on the line between Bathurst and Drummond townships. In Drummond it immediately runs under a heavy drift, and shortly after is capped by rocks of Lower Silurian age. The distance from Eagle lake to Balderson's Corners is about twenty-six miles. A remarkable feature of this band is that it immediately overlies a zone of rock containing magnetic iron ore and deposits of phosphate of lime. These minerals were observed in proximity to this limestone at Eagle lake, at Crow lake, in Bedford and Oso, and again at the Foley and McVeigh lots in Bathurst, in which last locality both have been mined to a small extent. The limestone has also interstratified with it a number of subordinate bands of red felspathic bands, which separate the whole into a number of unequal parts. The largest calcareous bed does not exceed 150 feet, but the total thickness from the base of the lowest bed of limestone to the top of the highest may be estimated at not less than 2,600 feet. The limestone is coarsely crystalline, and holds in abundance small scales of a yellowish-brown mica, and less frequently graphite.

"The Bob's lake, Tay river and Meyers lake is perhaps the most important band in the whole sequence. It is separated from the last by a great volume of gneissic strata, which has a transverse measurement of over 13,000 feet. This may or may not represent the actual thickness of the gneiss, as the strata are all in a nearly vertical attitude, and there is no evidence of any repetition of the beds. The limestone was continuously traced from the southern extremity of White lake in Bedford, across Green bay and Bob's lake, to the Tay river in South Sherbrooke, and thence along the general bearing of this river to and across Meyers or Christie's lake into the township of Bathurst, where its course is shortly concealed by heavy drift. The distance from White lake in Bedford to the last position in which the band was noted in Bathurst is about twenty-two miles. The thickness cannot be less than 2,600 feet, and the limestone differs in a marked manner from either of the four inferior bands. It resembles them in being white, but is much more coarsely crystalline. Graphite is abundantly disseminated through it in brilliant plates or scales, and there are also layers of white quartzo-felspathic rock associated with it, which occur both in the form of interstratified beds and irregular masses. This may, for the present, be considered as the

The following account is given by Mr. Vennor of the Watson mine at Christie's lake:

Watson mine at Christie's lake, South Sherbrooke.

"This location is situated on the eighteenth, nineteenth and twentieth lots of the third concession of South Sherbrooke, and embraces an area of 259 acres; the openings made are on the first and last numbered lots. On a high bluff on the north shore of the lake, on lot eighteen, three beds of iron ore have been uncovered and to some extent worked during the last summer. The strata, which here consist of dark grayish and greenish hornblendic gneiss, dip to the southward at angles varying from 15° to 80°. The uppermost bed of ore, and the nearest to the lake, has been uncovered for about thirty-five feet in length by twenty-four in breadth, and a considerable mass of ore has been exposed. No walls have yet been reached, and I think it is probable that the uncovering has been extended on the face of the bed rather than across its outcrop. In the second and underlying bed a breadth of eighteen feet of ore has been uncovered, and can be traced by openings made on its course for a distance of upwards of 150 feet. In the third and lowest bed a well defined foot wall of gneiss has been struck, and a solid mass of ore is exposed measuring eighteen feet in width. The extreme distance between the openings on this property on the strike of the ore beds is nearly one mile, and the distance between the top of the upper and the bottom of the lower bed of ore is about 300 yards. Several hundred tons of ore have been taken out, but operations have been chiefly confined to the determination of the extent of the deposits, which is now pretty satisfactorily known. An experimental shipment of the ore has been made to Cleveland, and it is reported to have given perfect satisfaction to the smelters, and it has further been ascertained that this ore will produce a quality of iron well suited for the manufacture of Bessemer steel. An analysis made by Dr. Harrington of a sample of the ore which I brought from this location gave as follows:

Metallic iron	65.62 per cent.
Titanic acid	2.83 "
Phosphoric acid	0.05 "
Sulphur	Not determined.

"It may be further stated that the facilities for mining here are favorable; the position of the ore on a high hill affords easy and cheap drainage, and a ready means of disposing of the *debris*, and these mines can probably be worked for a considerable time before resorting to expensive underground operations."[25]

Further explorations in Frontenac and Lanark.

More careful explorations of the counties of Frontenac and Lanark were made by Mr. Vennor during the season of 1874, and a number of newly discovered or until that time little known mining locations were noticed by him in the report of his work during that year. Several of these are deserving of mention. In the vicinity of Eagle lake, in the northeastern corner of the township of Hinchinbrooke and along the westerly boundary of Bedford, iron ore was found in several localities, principally on the twenty-sixth, twenty-seventh and twenty-eighth lots of the first concessions of both townships, but chiefly on the twenty-ninth and thirtieth lots of Bedford, near the lake shore. The magnetite occurs there in a bedded form associated with heavy, dark hornblendic and dioritic rocks, which in a number of instances are met with in close connection with the ores of iron in this section of country. Fair exposures of ore have been made at several places, but the beds are extremely

In Hinchinbrooke and Bedford townships.

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highest band of limestone in the series, and it belongs to the synclinal forms which I have yet to bring under your notice as occurring in Bedford and Loughboro'. It is overlaid by a considerable volume of gneissic strata in which there also occurs a small band of limestone—the Farren lake band—as noticed (Report of Progress, 1872-3, p. 160) but which may be left out of consideration for the present. At its base, and also at some distance above it, there are important deposits of magnetic iron ore, a fact which had already been dwelt upon in my previous reports."

[25] Geological Survey of Canada, 1872-3, p. 174.

irregular. The ore itself is described as a beautifully crystalline magnetite, yeilding according to Professor Chapman's analysis 62.52 per cent. of metallic iron. It also contains traces of phosphorus, a very small amount of sulphur and about 3.23 per cent. of titanic acid. One serious drawback however exists in the fact that apatite is associated with much of the magnetite, both in the form of grains and crystals. The crystals are easily separated from the ore, but the finely disseminated granular portions are so intimately intermingled as to be inseparable. A similar association of magnetite and apatite exists at the Foley mine in Bathurst, and appears to characterise the lowest horizon of iron ore deposits. Mr. Vennor mentions, in proof of the stratigraphical arrangement of the ores, that the position of the Eagle lake deposit in relation to the overlying band of limestone is the same as that of the Foley mine, and this band of limestone having been continuously traced from one locality to the other, a line may be drawn which will in all probability show the course along which other masses of iron ore may be expected to occur. Another characteristic of the iron ore of this horizon is that it is generally of a coarsely crystalline character, it being found both at the Foley mine and at Eagle lake in large octahedral crystals, the axes of which are often more than an inch in length, but the occurrence of these crystals would in itself be no proof of the deposit being a vein. "At Eagle lake," Mr. Vennor says, "the magnetite seems to occur as an unmistakable bed, and between the Foley and Eagle lake mines it is found in several localities in disseminated grains and strings in a peculiar stratified dioritic rock which is apparently made up of the same constituents as the more coarsely crystalline diorites, with no traces of stratification. These coarse varieties of diorite occur as lenticular or irregular shaped masses at perhaps two or more horizons, and they are often unaccompanied by iron ore." It is observed that most of the diorites are undoubtedly interstratified masses. In Hastings they are fine-grained, as is also the magnetite, while in Frontenac and Lanark, where the diorites are coarsely crystalline, the accompanying magnetites are of the same description.

Coarsely crystalline magnetic ore.

Silver lake and Christie's lake ores, in South Sherbrooke.

Another location of iron ores is in the vicinity of Silver lake in South Sherbrooke, where they were discovered during the summer of 1873. These, upon careful examination, were found on an extension of the iron ore beds of the northern shore of Christie's lake. They occur on lots 13, 14 and 15 of the fourth concession of South Sherbrooke, and openings made upon them showed the strike of the bed to be about northeast and southwest, with a steep dip to the southeastward. The ore is of much the same character as at Christie's lake, and is a compact, bluish-black magnetite containing about 64 per cent. of metallic iron and less than 2 per cent. of titanic acid. The following analyses show the close comparison between the ores of the two localities :

	Silver lake.	Christie's lake.
Magnetic oxide of iron	88.59	90.61
Titanic acid	1.75	2.83
Insoluble residue	5.75	0.05
Metallic iron	64.15	65.62

Tracing the Wolf lake deposit in Bedford.

Reference has already been made to a deposit of magnetic ore on lot 21 of the ninth concession of Bedford, near Wolf lake.[26] This location was carefully examined by Mr. Vennor with the dip needle, and he had reason to suppose that ore existed in considerable quantity. "The bed or beds of ore here," he says, "are undoubtedly on the course of the ferriferous horizon upon which is situated the Hon. G. W. Allan's deposit in North Crosby, and form an outcrop upon the opposite side of the synclinal which exists between these deposits and the Fournier and Bygrove mines. Other exposures of magnetic iron ore, near Wolf lake, on 24 or 25 of the tenth concession, are probably on the run of those on lot 21 of the ninth concession of Bedford. The two localities are fully one mile and a quarter apart, and it is more than probable that further discoveries will be made in the intervening country."

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[26] Ante pp. 35 and 43.

Spectacle lake deposits in North Crosby.

A mile to the eastward of Wolf lake, on 18 and 19 of the eighth concesion of North Crosby, are the Spectacle lake deposits. The ore occurs in diorite and appears to exist in considerable quantity, but it contains many impurities. The property was worked at one time by an American company, but after one shipment the enterprise was abandoned. Mr. Vennor observes that the position of the deposit at a considerable altitude in what has been termed the Westport mountains is against its future prospects.

Ore beds south of Christie's lake.

The beds of ore on the south side of Christie's lake are quite distinct from those already noted as occurring on the northern shore, being in a much higher horizon, although lower than the Fournier and Bygrove ores. They occur between the road and the lake on lots 17 and 18 of the eighth concession of South Sherbrooke, and are immediately beneath the highest or Farren's lake band of limestone. The ore is said to be of an excellent quality, resembling that of the Fournier and Bygrove mines, but it does not appear to exist in quantity.

The other deposits in this region referred to by Mr. Vennor are those known as Mitchell's and Gordon's, the former in the rear of North Crosby and the latter near the town line between South Sherbrooke and Bathurst, but little was known respecting their extent or quality. The following particulars are given of four of the more important deposits or mines in this district:

Vennor

In the township of Bedford.

"*Howse Iron Deposit.* This is one of a series of outcrops of iron ore which occur at intervals from the fourth lot of the first concession to the eight and ninth lots of the fourth concession of Bedford. These have been known for a great number of years, and specimens of the ore were obtained by the surveyors when laying out the township upwards of sixty years ago. But excepting the little work done on the Howse lot (lot four, concession one), during the years 1869 and 1870 (see Report of Progress, 1870-1, p. 312), the deposits have up to the present time remained as they were originally found. The shipment of fifty tons of ore from the Howse deposit, in the year 1869, to Charlotte, N.Y., as far as I have been able to learn, was attended with satisfactory results, at least as regarded the quality of the ore; but the long carriage, seventeen miles, over sandy and very hilly country to Westport village, on the Rideau, before it could be shipped to Kingston, proved a decided obstacle to the enterprise. The ores at the surface are not as pure as many of those in South Sherbrooke, and are more mixed with rock matter; still this is in a great measure compensated for by their nearness to the Kingston and Pembroke Railway. For it will be remembered that the very impure iron ores of the Chaffey mine, near Newboro on the Rideau, have been mined for years successfully, merely in consequence of their being upon navigable waters, although the ore besides containing 9.80 per cent. of titanic acid, only averages about 50 per cent. of metallic iron. The Howse deposit is of an exceedingly irregular character, and it would be a difficult matter to draw any definite outline that might be said to represent the shape of the mass of ore. The greatest length however is on the strike of the bed, namely, nearly northeast and southwest, and at one place the breadth appeared to be from fifteen to twenty paces. Through this last distance however there are several *horses* of rock. Beyond these facts I can state nothing respecting this deposit. That there is visible a great quanitity of ore is undoubted, and as it can be mined in the cheapest manner, namely, by open cuttings, there seems no reason why it should not be profitably worked. The position of this and the adjoining beds of iron ore is almost immediately beneath the Wolf lake, Crosby lake and Pike lake band of limestone, which is the southeastern

Vennor.

outcrop of the Bob's lake, Tay river and Meyers lake band, on the opposite side of a synclinal form. (See Report of Progress, 1873-4 p. 104). Consequently these ores are in the same stratigraphical position as those represented by the Meyers lake and Silver lake deposits. This fact of the occurrence of outcrops of iron ore in the same stratigraphical positions, on both sides of a synclinal form, is, I think, sufficient proof of the continuity of the ore, not only in length but also in depth. The occurrence of strongly rust-colored gneisses in many parts of the Bedford basin or synclinal, between Bob's and Potspoon lakes, convinced me that this ferriferous horizon is brought, or almost brought, to the surface by undulations in several places between the two divergent outcrops of ore. It also seems to me highly improbable that the iron ore should have only been deposited to the limited extent seen along the two outcrops of the same horizon of rock.

In the township of North Crosby.

“*Allan's Iron Ore Deposit.* This deposit of magnetite occurs on the twenty-seventh lot of the fourth concession of North Crosby. It is close to the town line of South Sherbrooke, and a little over half a mile southeastward of the Fournier mine. Nothing whatever has been done here since the autumn of 1868, and the excavation then made by the Hon. G. W. Allan is filled with water and *debris*. The question therefore as to the extent of the deposit yet remains undecided; but as the surface indications are promising and the ore of good quality it is altogether probable that mining might be carried on with profit for some time. The route to the Kingston and Pembroke railway is the same as that from the Meyers and Silver lake deposits, viz: *via* the Tay river and Bob's lake, and from the Allan deposit to the Tay river the distance is about two miles. For the purpose of reference and comparison I append a partial analysis of this ore, taken from the table of analyses, Report of Progress, 1873-4:

Magnetic oxide of iron	90.14=metallic iron, 65.27
Phosphorous	0.07
Titanic acid	1.03
Insoluble matter	5.25

The iron ore occurring on lot 27 of the seventh concession of North Crosby undoubtedly belongs to this horizon, but the distance between the two outcrops is about two and three-quarter miles.

In the township of South Sherbrooke.

“*Bygrove and Fournier Deposits.* Both of these deposits of magnetite occur in the first concession of South Sherbrooke and are in the same horizon. The Bygrove mine on the third lot has remained unworked since the year 1869, when it was to some extent worked by Mr. George Oliver of Perth. The Fournier deposit on the fourteenth lot however has from time to time been more or less mined. During the summer of 1873 the last attempt at raising this ore for the market was made. A shaft was sunk to the depth of one hundred and ten feet, and the company raised in all about 600 tons of good ore. At this depth however the deposit became very irregular and uncertain, and as the ore could not be extracted without the removal of much rock work was abandoned and has not been resumed since. I may here mention a fact respecting this iron horizon that is not generally known, namely, that at a short distance from the Fournier mine, on the fourteenth lot, the ferriferous belt passes beneath Farren's lake in the second concession, its strike changing and coinciding with the course of the lake. On its exit from the lake at its western end the zone again becomes clearly marked by the presence of iron, until on the third lot of the first concession we arrive at the deposit of ore constituting the Bygrove mine. Specimens of ore from these two deposits gave about an equal percentage of metallic iron, the Fournier yielding to analysis 59.59 per cent. and the Bygrove 59.55 per cent. In the Report in which these analyses were first given (Report of Progress 1871-2, p. 123) I further stated that the Bygrove and Fournier ores were free from titanium, and that it appeared extremely probable that they would be found to belong to beds 'somewhat higher in the series than the titaniferous ores.' This supposition has since been clearly proved. They have been found to lie in the highest iron-bearing horizon and immediately below the highest band of crystalline limestone. The second or underlying belt is that on which are situated the Meyers and Silver lake deposits, the ore from which as we have seen contains from 64 to 65 per cent. of metallic iron and invariably a small percentage of titanic acid; whilst in the next or third underlying belt represented by the McVeigh, Foley and Eagle lake deposits, the ore is more titaniferous, and is further characterized by its peculiar coarsely crystalline character and by the presence of apatite or phosphate of lime.

Vennor.

"I have thus I think with some degree of certainty succeeded in establishing the existence of three distinct horizons of iron ore, each of which possesses some peculiar characteristics by which it may be again recognized. Should such prove to be the case it will be a most important step gained, and an invaluable aid to future predictions respecting the iron ores of the Laurentian rocks."[27]

Three horizons of ore established.

In the prosecution of the work of the Geological Survey on the Quebec side of the Ottawa river, Mr. Vennor was enabled to make some interesting comparisons between the occurrence of iron ores in the Ontario and Quebec districts. In the Report for 1876-7 he observed that the iron ore horizons marked by several iron mines in Hull and Templeton are in precisely the same relative stratigraphical position as the ore horizons of South Sherbrooke and North Crosby, as illustrated by the Silver lake, Christie's lake, Fournier and Allan mines. These horizons are beneath the true apatite-bearing rocks, although a few deposits of apatite have been found occasionally associated with and beneath them. One feature in connection with the iron ore deposits in the Ottawa section is deserving of mention, namely, the intermixture and interstratification of hematite with magnetite. In no one instance, Mr. Vennor says, does this condition occur in the corresponding iron horizons in South Sherbrooke or North Crosby, where the ore is invariably a crystalline magnetite. Hematite frequently occurs in Lanark county, both below and above the magnetic ore horizons, but always by itself or in association with apatite and pyrites. The distance between the South Sherbrooke and Hull deposits is about fifty-six miles in a direct line, and although no other important deposits of ore intervene this is mainly owing to the fact that most of the intermediate country is occupied by the flat-lying rocks of the Lower Silurian formation, which entirely conceal the lower crystalline rocks. The fact however that iron ore occurs in workable quantity in Hull township immediately where the crystalline limestones and gneisses first again become well exposed, gives, in the opinion of Mr. Vennor, considerable encouragement to those interested in this ore respecting its permanency in certain horizons of rock. "It must be borne in mind," he says, "that iron ore though often in all appearance a clearly interstratified mass is not a continuous deposit. It may occur at intervals for many miles in a section of country, and yet between the exposures of ore there may not be the slightest indication of its existence. Most of the large deposits of iron ore in eastern Ontario and in Ottawa county are exceptional occurrences, and their unusual extent is due to the recurrence of the outcrops of ore on anticlinal and on synclinal folds of the strata. For example the Big Ore bed in Belmont exhibits an anticlinal and synclinal fold; the Seymour ore bed in Madoc is a decided synclinal, in which two outcrops of iron ore each fifteen feet in thickness are sharply folded the one upon the other; while the great Hull iron ore bed consists of an anticlinal of magnetic ore through which breaks an inferior band of crystalline limestone. So often indeed is the importance of an iron ore deposit due to one or other of these forms that I have for some time been in the

Comparisons of occurrence of iron ores in Ontario and Quebec.

Relation of ore deposits to rock foldings and dislocations.

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[27] Geological Survey of Canada 1874-5, pp. 112-22.

habit of directing prospectors to such points as those in which the strata folded over or under the axis of an anticlinal or synclinal, and so far many of the trials made at these points have been successful. Dislocations of the strata, or faults with their accompanying dykes and lodes, have also much to do with some of the larger deposits of iron ore."[28]

HARRINGTON'S REPORT ON THE IRON ORES OF CANADA.

A valuable report on the iron ores of the Dominion was made by Dr. Harrington of the Geological Survey in 1874, and published in the report of the Survey for that year. A summary of this report, in so far as it concerns the Province of Ontario, is presented below:

Origin of iron ores: chemical and mechanical concentration.

Referring to the origin of the iron ores, Dr. Harrington states that from the Laurentian days down to the present processes of chemical and mechanical concentration have been in operation which have resulted in the formation of beds and veins of ore. The processes have doubtless, he thinks, differed in kind to a certain extent, and they have operated under more or less favorable conditions; and subsequently to their deposition the ores have frequently been subjected to agencies which have deprived them of their original nature, so that it is not surprising to find them differing widely in chemical composition and physical characters. Three classes of ores are treated of in the report, viz., (1) anhydrous oxides, embracing magnetic iron ore or magnetite, hematite, including crystalline and earthy varieties, and titanic iron ore; (2) hydrous oxides, including limonite or brown hematite, and bog ore; and (3) carbonates, including spathic ore and clay ironstone. The last-named ore, it may be observed, has not yet been discovered in the older parts of Ontario, but a large bed of it has been noticed by Dr. Bell on the Mattagami river near latitude 50° 30′ north and longitude 82° west. The most important deposits of magnetic iron ore occur in rocks of Laurentian and Huronian age, but it is also found in rocks which have been referred to the Lower and Upper Silurian, as well as in the Devonian and Trias.

Veins and beds of magnetic ore.

There are few opportunities for studying the character of the Laurentian and Huronian magnetites in our country as compared with those afforded in Norway and Sweden, and also in New York and New Jersey; but Dr. Harrington observes that while the larger and more important deposits such as Big Ore bed in Belmont are interstratified beds, true veins of magnetic iron ore also occur. Thus at the Foley mine in Bedford the country rock, which is a diorite showing little or no indication of bedding, is cut not only by the deposits of magnetite but also by veins of coarsely crystalline calcite, the two minerals being in some instances associated. In the undoubted beds the magnetite is generally granular or massive, but does not occur in large crystals of definite form. In New Jersey the workable deposits of magnetic ores are regarded as of sedimentary origin, though formerly believed to be eruptive. "The latter view was also taken by Sir Roderick Murchison as to the origin of some of the rich deposits of magnetite in the Urals, and many of the deposits of magnetite in Norway and Sweden have been considered as eruptive by Durocher and others. None of the Canadian magnetites, so far as I am aware, have ever been regarded as eruptive, at least by the officers of the Geological Survey." It will be found hereafter that this opinion has been held by at least one officer of the Survey.

Sedimentary magnetites.

On the origin of our sedimentary magnetites the question arises as to whether they were deposited as such, or in some other form and afterwards altered to magnetite. In some cases beds may have been formed by the accumulation of iron sands, as they are forming in the gulf of St. Lawrence today, the material being derived from the disintegration of pre-existing crystalline rocks, in which case they might be expected to contain not only magnetite but ilmenite; but Dr. Harrington thinks it probable that in general their origin has been similar to that of the modern bog and rock ores.

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[28] Geological Survey of Canada, 1876-7, pp. 297.

"Deposits of magnetite as a rule do not continue of uniform thickness for any great distance like the enclosing rocks, and this is just what might be expected if we suppose them to have originally occurred as bog or lake ores which accumulated in local hollows or depressions. No ore moreover would be more readily converted into magnetite than bog ore, on account of the considerable proportion of organic matter which the latter contains. In this connection may be described a very simple but interesting experiment tried with a specimen of bog ore from L'Islet containing about 22 per cent. of water and organic matter. The pulverized ore was placed in a platinum crucible and heated for an hour at a temperature of 190° F. At the end of that time it had parted with its combined water, or at any rate with sufficient to cause the color to change from brown to bright red. It still however retained organic matter, and on heating for a few minutes in a tightly closed crucible and at a temperature considerably below redness a reduction of the peroxide ensued and a black, strongly magnetic powder was obtained, apparently consisting of magnetic oxide and not of metallic iron, as it occasioned no precipitation of metallic copper in a solution of the sulphate. The cover was now removed from the crucible and a red heat given, when in a short time the powder again became red, or rather purplish-red, and non-magnetic. Finally the heat was raised a little higher (to bright redness), and soon the powder became black and strongly magnetic, having apparently parted with a portion of its oxygen. These changes are instructive, for while brought about in the laboratory they might take place in nature. They show too that in some cases magnetites may have been formed from such ores as bog ore at comparatively low temperatures, the reduction being due to the organic matter of the ore. That a magnetic oxide should be converted into a non-magnetic oxide, as described above, is a curious fact. It is generally stated also that peroxide of iron requires a white heat to convert it into magnetic oxide, but the heat of an ordinary Bunsen burner has been found to readily convert limonites, even when free from organic matter, into magnetic oxide."[29]

Harrington.

Conversion of bog ore into magnetite.

At the Hull mines on the east side of the Ottawa river the magnetite occurs in crystalline limestone containing graphite, mica and pyroxene, but the latter more rarely. At the Big Ore bed in Belmont the ore is interstrati-

Variations of occurrence.

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[29] It is the opinion of Messrs N. H. and H. V. Winchell of the Minnesota Geological Survey that similar changes have taken place in the iron ores of the Vermilion schists in that state in the same way, but upon a grand scale. "Magnetite," they say, "differs from hematite in having a greater ratio of iron to oxygen, and in its crystalline system. Magnetite is found in the primary eruptive basalts, where it is one of the essential characteristic minerals. By greater oxidation it is converted to hematite, which is frequent in the metamorphic rocks. When magnetite is found in the metamorphosed rocks it is generally at points and planes of contact with eruptive dykes whose pressure, heat and percolating hot solutions have concentrated the iron from surrounding rock masses. When it constitutes ores in the metamorphic rocks, as in the Vermilion series of schists, it is disseminated either as an ingredient of a massive basic rock, or it is interlaminated with siliceous sheets which are similar to those of 'chalcedonic' quartz in the jaspelite of the Keewatin schists. Structurally it repeats the characters of magnetite in the eruptive gabbro on the one hand, and of the hematites of the Keewatin on the other. It is necessary to consider therefore only the laminated condition, since the massive deposits can be referred directly to dynamic and thermal agents. These laminated deposits of magnetite are embraced sometimes in undoubtedly eruptive basic rock. The change therefore from hematite to magnetite through the action of heat and moisture seems to be one of the common phenomena of metamorphism." It is of the same general character as the authors' show to have taken place in other minerals of the Keewatin schists, viz.: "a step back toward the condition which the constituent iron molecules had when they were erupted with basic lava from the interior of the earth." (The Iron Ores of Minnesota, 1891, p. 21.) The iron ores found in the Vermilion series of rocks in Minnesota are magnetites, whereas by far the larger part of ores in the Mesabi range are hematites; but in his paper on the Mesabi Iron Range (1892) H. V. Winchell shows that in the eastern portion of it, near Gunflint lake on the Ontario boundary, the ore is magnetite and "probably owes its magnetic properties to the heat of the gabbro overflow upon the hematites which were deposited in the rocks at the time of their formation in the oceanic waters."

fied with diabase, greenish epidotic and chloritic rocks and crystalline limestone. At the Seymour bed in Madoc the ore is underlaid by a thin band of soft mica schist, and overlaid by reddish-gray highly felspathic rocks, in places porphyritic, and occasionally passing into syenite or syenitic gneiss. At the Chaffey mine the ore occurs in coarsely crystalline gneiss containing both mica and hornblende, the gneiss adjoining a band of crystalline limestone. On the Quinze river in northern Ontario, Mr. McOuat found magnetic iron ore interstratified with quartzite, the ore forming layers from the thickness of paper to about an inch, and interlaminated with similar layers of whitish-gray and dull red fine-grained quartzite. Here the iron ore constitutes probably from a fourth to a third of the whole, and as the thickness of the whole band is about thirty feet the total thickness of the layers of iron would probably be not less than eight feet. Dr. Harrington observes that some of the Michigan ores occur in an analogous manner, and are considered to be of Huronian age. Concerning the occurrence of iron ore in beds of diorite, as at the Foley mine, he says it is quite impossible to distinguish the rock from diorites of igneous origin, saving that it appears in general to follow the sinuosities of the beds on either side of it, and is sometimes seen to blend into hornblendic and micaceous schists. But the term "diorite" strictly speaking belongs to an igneous rock, and there seems to be no good name for a similar aggregate of a sedimentary origin. In Hastings and Addington, as well as elsewhere in Ontario, fine-grained diorites occur, but those which are associated with magnetic iron ore in the townships of Bathurst and South Sherbrooke in Lanark are generally coarse-grained, and often contain scales of dark-brown mica, grains of magnetic iron ore and small quantities of quartz These observations illustrate the variable character of the rocks adjoining deposits of magnetite in our old crystalline series, but while it is exceptional to find such deposits in limestone they frequently occur near the junction of other rocks with it. "This fact should always be kept in mind in tracing or searching for magnetites, as the limestone bands are continuous and constant in character for long distances."

A fact worth noting by explorers.

Following is a table of analyses of magnetites given by Dr. Harrington, the first four of which were made by Dr. Hunt and the fifth and sixth by Prof. Chapman.

Analyses of Ontario magnetites.

	I.	II.	III.	IV.	V.	VI.
Peroxide of iron	69.77	90.14	72.80	89.22	58.35	59.39
Protoxide of iron	....	....	....	....	24.87	26.93
Oxide of manganese	....	traces	....	none	0.13	traces
Alumina	5.65	1.33	....	....	0.42	0.67
Lime	....	0.82	1.69	none	1.43	0.33
Magnesia	4.50	0.84	6.86	....	2.56	0.82
Phosphorus	0.085	0.007	0.035	0.012	0.07	traces
Sulphur	1.52	0.12	0.027	0.073	0.04	0.07
Carbonic acid	....	....	1.50	....	....	....
Silica	7.10	....	....	....	11.17	....
Titanic acid	9.80	1.03	....	....	0.73	3.23
Graphite	....	....	....	....	....	....
Water	2.45	....	3.50	....	....	....
Insoluble matter	....	5.25	14.73	10.42	....	8.38*
Totals	100.875	99.537	101.142	99.77	99.77	99.82
Metallic iron	50.52	65.27	52.72	64.61	60.19	62.52

*Silica and insoluble rock matter.

In this table the first column represents the Chaffey mine in South Crosby, the second Hon. George W. Allan's mine in North Crosby, the third the

Sand-pit bed of Belmont at Blairton, the fourth the Seymour mine in Madoc, the fifth the deposit on lot 20 in the first concession of Snowdon, and the sixth a deposit on lot 29 in the first concession of Bedford.

Varieties of hematite ores.

Harrington.

Occurrence of hematite.

Under the name of hematites are included several varieties of ore consisting of the anhydrous peroxide of iron; crystalline varieties with metallic lustre are either specular or micaceous; while the earthy varieties, often containing clay, are known as red ochre, and between the crystalline and the ochrous ores comes red hematite. As a rule hematite is freer from impurities than magnetite. It is not so easily reduced as hydrated oxides or carbonates, and is liable to produce gray rather than white iron, a fact of importance in connection with the manufacture of Bessemer pig. "Hematite occurs in both beds and veins, the beds generally, though not always, being the more important deposits. Like magnetite it is not found solely in any one kind of rock, but often in rocks of most diverse characters. A few examples illustrative of this fact may be of interest. Beginning with the Laurentian, we find at the McNab mine near Arnprior a compact red hematite occurring in crystalline limestone. The bed is inclined at a high angle and has been worked to a depth of about eighty feet, when it is said to have thinned out. At the Dalhousie mine, twelve miles from Perth, a compact red hematite somewhat similar to the McNab ore also occurs in limestone, although at one point in the workings a soft chloritic looking slate with numerous crystals of pyrites seems to intervene between the ore and the underlying limestone. The limestone is highly crystalline; that underlying the main deposit being white and containing large quantities of tremolite, while that which overlies it is stained red with peroxide of iron. When the mine was opened up there appeared to be two beds cropping out in places at the surface with four or five feet of limestone between them. The uppermost and smaller of these was found to run out at a few feet in depth, and to extend but a short distance in the direction of the strike. The larger deposit was in places as much as nine feet thick at the surface, and at a depth of eighty feet had an average thickness of four or five feet. Among other examples of the occurrence of hematite in Laurentian limestone may be mentioned the thin vein of specular ore on lot two, range four of Elzevir (Geology of Canada, 1866, p. 101), and the finely-granular hematite of Iron island, lake Nipissing." No important deposits of hematite have yet been discovered in our Huronian rocks, like those of Michigan, but where they have been found they are very similar in the mode of occurrence, consisting for the most part of alternate layers of compact hematite or specular ore and quartzite or jasper, in dioritic or diabasic rocks. In the following table are given analyses of several ores from different mines in Ontario:

	I.	II.	III.	IV.
Peroxide of iron	84.42	84.10	82.25	86.80
Protoxide of manganese				
Alumina				
Lime	3.02	4.93	trace	none
Magnesia	0.50			
Phosphoric acid	0.03*		0.026*	trace
Sulphur	0.065			0.092
Carbonic acid	2.93	3.87		
Silica		4.00		
Titanic acid				
Graphite				
Water			0.66	
Insoluble matter	7.160		16.05	12.75
Totals	98.125	96.90	98.986	99.642
Metallic iron	59.09	58.80	57.60	60.76

*Phosphorus.

The first is from the McNab mine near Arnprior, the second from the same locality, the third from the Dalhousie mine, and the fourth from Gros Cap on lake Superior.

Workings of Ontario mines.

Referring to the production of several mines in Ontario, Dr. Harrington says the Blairton or Big Ore bed of Belmont was in 1872-3 the largest in the country, the output for that fiscal year amounting to nearly 30,000 tons. In July of 1873 ore was shipped to Pittsburgh at the rate of 300 to 400 tons a day. The Yankee and Chaffey mines together had for several years been producing between 7,000 and 8,000 tons, and were the demand for titaniferous ores greater the production of these two mines could readily be increased. From the Dalhousie mine 3,000 to 4,000 tons had been annually raised and shipped for several years, but although the ore was one of the finest in the country the work had recently been stopped at this mine owing to the dulness of the market. Several hundred tons of very fine ore had also been taken out of the Fournier mine in South Sherbrooke during the winter of 1872-3.[30]

COSTE'S VIEWS ON OCCURRENCE OF ORES IN ARCHÆAN ROCKS.

Report on the Madoc and Marmora region.

Reference has been made to the views of Mr. Eugene Coste on the mode of occurrence of iron ores in the Archæan rocks, differing essentially from the views of other officers of the Geological Survey. Mr. Coste's report on the Madoc and Marmora region, in which he proposed to treat in detail of the metamorphosed primitive rocks and "to establish and explain the nature and relations of the deposits of iron ore and of the auriferous mispickel and quartz veins, with the granitic and dioritic igneous masses,"[31] has not yet been published; but the following extract from the report of 1887-8 presents a summary of his conclusions:

Coste.

"The object of this paper is to present in a concise form the conclusions arrived at by the writer as to the mode of occurrence of the iron ores and phosphate deposits in the Archæan rocks of Canada after a careful and minute study of many of these deposits in the iron and phosphate districts of Ontario* and in the counties of Ottawa and Pontiac in Quebec. It is here presented on account of the practical bearing that it may have on the future developments of these important deposits, as it is hoped that it will be found to be a strong encouragement for the working of many of these deposits in depth as well as a guide in the following of their irregular structure and a help in the further discovery of new deposits of these minerals. We think we may say that our conclusions will be found to be greatly at variance with the views generally admitted here in Canada, expressions of which have been published principally in the different reports of the Geological Survey, and especially in the Geology of Canada, 1863, and in the well-known subsequent reports of Dr. Hunt, Dr. Harrington and H. G. Vennor. For indeed we believe that we have gathered year after year strong and clear evidence to show that not only our deposits of iron ores in the Archæan rocks are of an eruptive or igneous origin, but also that our deposits of phosphate are exactly similar and have also the same origin. This is why we are treating here of the deposits of these two minerals together as we believe that they are exactly analogous, and that which can be said for one is applicable to the other. As far as the iron ores are concerned, the view of their deposits in the Archæan rocks being of an eruptive origin is far from being a new one, and has been held by a great many eminent geologists in many countries, principally I believe in France, Norway and Sweden, and also by some of the English and American geologists. In the case of the phosphate (apatite) the

Eruptive origin of iron ores and phosphate in the Archæan rocks.

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[30] Geological Survey of Canada, 1873-4, pp. 192-259.

[31] Geological Survey of Canada 1886, p. 20A.

*Counties of Haliburton, Victoria, Peterborough, Hastings, Frontenac, Leeds, Lanark and Renfrew.

Coste.

eruptive or igneous origin has also been advanced in Norway and in France, but by a smaller number of observers, probably on account of the fact that the apatite deposits are not so numerous as those of iron ores, and thus the opportunities for examination and report were less frequent. Here in Canada this eruptive origin of the apatite as well as of the iron ores has always been denied so far; and if my conclusions were not backed by so many facts, some of which were only brought to light in the workings of the mines in the last few years, I would feel somewhat reluctant to go thus entirely against the views already arrived at in this country by several very able men, but these facts were repeatedly observed and have been very carefully ascertained. The principal among these observed points are the following:

Observation of facts to support the theory of eruptive or igneous origin.

"1. About thirty different deposits of iron ores (principally magnetite, though sometimes hematite) have been geologically surveyed by us* in the Madoc and Marmora region of Ontario, and were found to occur in the form of irregular veins around and always in close proximity to a large granite mass, or to dykes and bosses of granite derived from it. The granite intrusions clearly cut across the Archæan crystalline limestone and schists, and the deposits of iron ores are also manifestly veins cutting in a like manner across the Archæan rocks.

"2. Away from the main granitic bodies, in the region covered by the map above referred to, there are no large deposits of iron ore, and when small quantities occur there can be seen almost in every case a small dyke of granite along the iron ore; so that the intimate connection of the two cannot be doubted.

"3. An exactly similar connection was also observed between the iron ore deposits and intrusive igneous masses in a more extended region of several thousand square miles, also geologically surveyed by us,† and comprising parts of the counties of Hastings, Peterborough and Victoria, in Ontario. There the iron ore deposits such as those forming the Blairton mine, Orton mine, Baker mine, Emily mine, Coe Hill mine, Jenkins mine, the Snowdon mines, etc., were always found to be intimately connected in the manner described above with many varied kinds of igneous rock, such as granite, granulite, pegmatite, mica syenite, hornblende syenite, diorites and diabases.

"4. In the region north of Kingston, in the counties of Frontenac, Leeds, Lanark, Renfrew, Pontiac and Ottawa, many deposits of iron ores and many deposits of phosphate were observed also in the same association with igneous rocks, and both cutting through the Archæan rocks. In the case of the phosphate the igneous rock was often the rock termed by Dr. Hunt 'pyroxenite,' but at other times it was a pegmatite or a mica syenite or a pyroxene syenite. In that region the iron ore and the phosphate have been found in the same deposits, as witnessed by the evidence at the Foley mine, the Forsyth mine, and especially at the Blessington mines, where the writer observed the apatite and the magnetite together in the workings of nine different pits, and where at the time of his examination last summer there were between 500 and 600 tons of iron ore and about 1,500 tons of phosphate on the dumps, the two minerals having been taken out from the same pits.

"5. In the two regions mentioned above, the apatite and magnetite were often seen to be amongst the component elements of these masses or dykes of

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*This map on the scale of forty chains to one inch, and comprising an area of one hundred and twenty-five square miles, is now in the hands of the engraver and is expected to be ready shortly. It will be accompanied by a report in which the details of our observations will be given at length.

†A map of about 3,500 square miles covering this region has been prepared and is expected to be published at the scale of four miles to the inch in the course of a year or so.

Coste.

igneous rocks, which rocks were observed to accompany these minerals in their deposits as a veinstone of quartz or calcite carries other minerals in other veins.

The ore deposits consequently of deep-seated origin.

"Considering all this, and knowing that similar facts have also been observed in other countries, especially in the states of New York and New Jersey, and in Norway and Sweden, it is only natural that we should conclude, like many other geologists have done before in those countries, that the iron ore and phosphate to be found in our Archæan rocks are the result of emanations which have accompanied or immediately followed the intrusions through these rocks of many varied kinds of igneous rocks which are no doubt the equivalent of the volcanic rocks of to-day. These deposits then are of a deep-seated origin, and consequently the fears entertained principally by our phosphate miners that their deposits are mere surface pockets, are not well founded. These fears are no doubt partly the result of the belief which has been somewhat prevalent that the apatite in them was the metamorphic equivalent of the phosphate nodules of younger formations, and it may be also that they have resulted from the fact that the apatite is irregularly distributed in these deposits and is often suddenly replaced by rock; this is not so often the case in the iron ore deposits which are on a larger scale. But notwithstanding this, when the deposits are properly understood to be, as we hold they are, igneous dykes and veins accompanying the igneous rocks, it will be easily seen why in the deposit itself the economic minerals can be suddenly replaced by rocks which may be said to be nothing else but the gangue. If this origin is understood it will besides facilitate and encourage the working of these deposits in depth, because the accompanying igneous rock forming a mass or a dyke alongside the deposit will be easy to follow, and, because if it is apatite or iron-bearing at the surface, it will always be a guarantee that it will also be in depth, as each separate mass of igneous rock is generally quite constant in composition."[32]

IRON MINES IN EASTERN ONTARIO.

Iron mines along the Kingston and Pembroke Railway.

The construction of the Kingston and Pembroke Railway had for one of its chief objects the affording of facilities to open up and work some of the iron ore deposits in the counties of Frontenac and Lanark, to which reference has been made in the foregoing pages. The deposits in the region of this railway are usually found in belts running in a northeast and southwest direction, parallel with the strike of the formations. The largest deposits are almost always found where the limestone and granite, gneiss or syenite come into contact, and this is largely true also of the iron ores in districts north and northwest of lake Superior. Magnetic ore is the principal variety, but specular ore has been discovered in several localities. Mr. William Rattle, an American mining engineer, who explored the district a few years ago, stated to the Mining Commission that he had found specular ore in several localities on a range in Darling. In one place he was shown a vein of magnetite 35 feet in width, and in another a bed of hematite at least 15 feet in width which he had traced 200 feet. Messrs. Bawden, Folger and Grady gave particulars to the Commission of the working of various mines along the line of the railway, of which the following is a brief summary:

Glendower mine.

The Glendower mine in Bedford is four miles east of the railway line, and is connected with it by a branch built in 1884. A large plant was erected and work was carried on upon an extensive scale for four or five years. The ore is magnetic, and runs from 50 to 60 per cent. of metallic iron. Near the surface it was clean and of fine quality, but at a depth of 120 or 130 feet it was found to contain sulphur, and operations were discontinued. At the bottom of the shaft the vein was 20 to 40 feet wide, the ore averaged 60 per cent. and the mine was in a position for raising 400 to 500 tons per day. Two or three other openings were made in the same locality, and numerous deposits are known to exist there. A bed of red hematite on lot 2 in the seventh concession has a width of 40 feet.

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[32] Geological survey of Canada, 1887-8, pp. 62-4s.

Mississippi mine.

North of the Mississippi river several locations have been worked in the township of Lavant. From one of these, the Mississippi mine, between 30,000 and 40,000 tons were taken out and shipped to Pennsylvania.

Wilbur mine.

The Wilbur mine in Palmerston lies between two bands of crystalline limestone, and about 100,000 tons of ore was taken out of the several shafts on the property. It was free from sulphur and phosphorus, and averaged about 50 per cent. of metallic iron, some analyses going up to 68 per cent.

At Calabogie lake.

Near Calabogie lake two shafts have been sunk and considerable quantities of ore have been raised, but it is said to have too much phosphorus for Bessemer iron.

The drop in the price of iron ore in United States markets which occurred while these mines were being opened led to the closing of the works, and scarcely any attempt has since been made to prove new locations or even to prospect for ore.

Iron ores on the line of the Central Ontario Railway.

In the county of Hastings the Central Ontario Railway was built at a cost of $2,000,000 to connect iron locations in the northern part of that county with lake navigation at Trenton. A large deposit of magnetic ore at Coe Hill in Wollaston was opened and worked for some time, as related in the statement of Mr. Ritchie, but for reasons mentioned by Mr. Ritchie operations were discontinued there. Prospectors report the existence of numerous and large deposits of ore in localities near to this line of railway and northward of its terminus, but no work has been done upon them to prove their extent or quality.

Belmont Bessemer Co.'s mine in Belmont.

A promising show of magnetic ore occurs on lot nineteen in the first concession of Belmont, the property of Mr. Ledyard of Toronto. It was leased in 1891 to the Belmont Bessemer Ore Co., and a railway is being constructed to the property. The deposit is said to range from 20 to 150 feet in width, and test borings have been made to depths ranging from 30 to 100 feet. The superintendent, Mr. Woodworth, informs me that little work was done last year owing to the depressed condition of the ore market, but numerous samples have been analyzed. The average of twenty-three samples made for the company gives the following result:

Metallic iron	65.333
Phosphorus	.016
Sulphur	.0747
Silica	4.303
Titanium	.743

This includes a lot of 100 tons sent to the Cambria Iron Co. of Pennsylvania, which gave 61.08 iron, .0225 phosphorus, .497 sulphur and 7.84 silica. A fifty-foot drift has been driven from a shaft at a depth of 40 feet, partly in ore and partly in what seems to be the foot wall. The mine is provided with steam boiler pumps, drill, hoist and suitable buildings, and can be put into good condition for shipping ore as soon as the railway is completed. This road is 9½ miles in length, and connects with the Central Ontario Railway two miles south of Marmora village. A further account of this mine is given in the statement of Mr. Ledyard, made to the Bureau as follows:

Ledyard.

The Belmont mine.

"I am a dealer in mines, more particularly iron, and have been engaged in the business for twenty years more or less. I own the Belmont mine, which is leased to the Belmont Bessemer Ore Company of New York. They are not actually working the property at present; but they have done sufficient development work to warrant them in building a railway into it, and they say they expect to have this railway completed next spring. So far as the

Ledyard.

Extent and quality of the ore.

extent of the deposit of ore is concerned the development which I did on the property showed a needle attraction of 600 feet in length by about 400 feet in width in some places; the company claim to have found a considerably greater length. I sank prospecting pits; the company have put down shafts; they have one 50 feet in depth which showed ore all the way. They have had diamond drilling done to a depth of about 100 feet. At 90 feet in No. 1 drill hole the ore was wonderfully pure, running very high in iron and almost absolutely free from impurities—not a sign of sulphur. The ore was particularly good at 90 feet, but it varied as all magnetic deposits do in its mixture with rock. This company propose to work the property and export the ore to furnaces in Pennsylvania. They have their buildings erected and all their hoisting machinery and other plant prepared to go to work. Within a month's time they could probably have the railway finished and be at work if the market warranted. The low price of ore has kept them back, otherwise they would have been at work last year. The analysis of this ore shows it to be very similar to the Lake Angeline and Pittsburgh Mining Company's ore, which is the very highest grade. This ore comes from Marquette district, in the state of Michigan. Both myself and the company have had analyses of the ore made. Following are some of these:

Analyses.

Assayer.	Locality.	Iron.	Phos.	Sulph.	Silica.	Tit. Ac.
Molin	East Pit	70.326	.0056	.0023	.875	.000
"	North "	55.240	.019	.0000	11.200	.000
"	South "	60.376	.037	.007	.000	.000
"	Shaft No. 1	63.131	.023	.004	.000	.000
Scranton	No. 1	65.36	.005	.000	4.50	.000
Cambria	N. & S. Pit	68.83	.008	.000	1.96	.06
"	"	69.99	.012	.000	3.10	.15
S. of S., Toronto	Surface	64.26	.000	.040	.000	.000
Fisher	South Pit	68.88	.006	.000	3.18	.000
"	East Pit	69.85	.013	.012	.000	.000
Ledoux	Var. places	66.55	.013	.096	2.43	.000
"	No. 3 Pit	69.85	.013	.012	.000	.000
"	No. 2 Pit	68.33	.016	.037	.000	.000
Molin	East Pit	69.630	.003	.005	....	.000
"	No Pit	62.667	.013	.384	....	.000
....	Drain Hole 1, 75ft	60.376	.004	.002	....	.083
....	" 70ft	65.104	.005	.074	3.83	.004
Pa. Steel Co	100-765 sample	68.930	.007	.000	4.12	....
Cambria Iron Co	100 tons	60.401	.022	.497	....	....
"	"	61.76	.023	....	7.84	....
Molin	....	67.309	.007	.130	....	....
"	....	69.630	.007	.158	....	....
"	....	71.951	.003	.041	....	....

"A number of analyses have been made by Mr. Molin of 20 Liberty street, New York, a well known Swedish expert. He has an article in the Engineering and Mining Journal of November 19th, 1892, in which he gives his opinion of this ore. The average of the samples he analyzed shows metallic iron 65.1 per cent., phosphorus .005, sulphur .074, titanic acid .04. The company state that an ordinary analysis shows no titanium at all, and that it is only by a very delicate test that it can be detected. The ore is a remarkably soft, fine ore. You will see what Mr. Molin says as to the suitability of the ore for making not ordinary Bessemer, but the very finest grades of steel. The phosphorus, as you will observe, is only .005 per cent. This property is in Peterborough, immediately adjoining Hastings county, hardly seven miles from Marmora village.

Iron ore properties in Snowdon.

"I have also some iron properties in the township of Snowdon, in Haliburton, consisting of lots 25 and 27 and 30 and 31 in the fourth concession. These I have developed by sinking shafts on them to some extent. Lot 26 belongs to Mr. Howland, and the Howland mine is situated on it. There are one or two other places in that neighborhood which show promising signs of ore, but it is doubtful if it is present in large quantity. There is also the Paxton mine in Lutterworth, out of which about 1,000 tons of beautiful ore was taken. This is in the section of country with which I am most familiar. Experts say that the formation in Snowdon is just the right formation for iron ore in quantity, and that from what they can see there is sufficient ore there to warrant mining on an extensive scale.

Ledyard.

Howland and Paxton mines.

"I should think a smelting furnace in Toronto could very profitably use these ores, but hematite would be required to mix with them. It is not quite so clear where the supply of hematite could be got. I found some in Belmont, which looks promising, but there has not been sufficient development to prove the quantity; it is just south of the magnetic deposit which the Belmont Bessemer Company is working."

Extensive ranges of magnetic ore extend from the township of Snowdon in an easterly direction across Haliburton, Hastings and Addington into Frontenac. Mr. Pusey, whose statement is given below, describes the ranges as running parallel to each other at an average distance of ten miles, and at intervals the ore occurs in large bodies and generally of good quality; but in one locality where the mass is very great it bears a high per cent. of titanium. In an interview Mr. Pusey gave the following information to the Bureau:

Iron belts extending from Haliburton to Frontenac.

"I am manager of the Bancroft Iron Company; we are building a railway from a point near Kinmount on the Victoria branch of the Midland Railway eastward through the townships of Snowdon, Glamorgan, Monmouth, Cardiff, Faraday and Dungannon. East of the last named township we have not yet located the line, but explorations have been made recently which prove that large and rich bodies of ore exist in Barrie, Clarendon and Frontenac. Our object in building this road is to develop the mineral interests in that section of the Province. We have ten miles completed and in operation, and ten miles more ready for laying the rails, which will be put down early in the spring. The road leads to some very valuable iron deposits in the townships of Glamorgan and Monmouth; the iron ore there occurs in two distinct ranges running in a northeast and southwest direction, which at their western ends are about ten miles apart, but approach each other and are almost merged into one range in the township of Dungannon in the county of Hastings. There is more crystalline limestone found in the southern range than in the northern one; in the latter there is more of a red syenite. The ores of the north range are much richer than those of the south range, but both are magnetic. There is very little hematite or indication of hematite in the north range, but indications of this variety of ore exist on the south range. Outcroppings of ore are found along both ranges; there are barren stretches and then numerous deposits of ore, seemingly clustered. So far as we have explored the north range it appears to be about one mile in width, but the width varies; we have never explored north of a certain line, the line forming the southern boundary of the nine townships belonging to the Canada Land and Emigration Company. The south range will vary from five to ten miles in width. You will find the same class of ore over five miles south of our deposits, but we have never explored very much south of say a mile in width through that section. We have found outcroppings of ore at frequent intervals on both ranges through the townships of Glamorgan, Monmouth, Cardiff, Faraday and Dungannon, a total distance of say fifty miles. We have explored by sinking test pits or shafts at seven or eight different points on the north range within the fifty miles. We have found the ore to be very rich; all the analyses show 70 per cent., not varying more

Pusey.

Construction of a railway to open up iron ore locations.

A double belt 50 miles long.

Pusey.

than one per cent. in any case. Following are analyses of three samples of ore from the north range :

Analyses of ores in north range.

——	1	2	3
Sesquioxide of iron	67.14	67.27	
Protoxide of iron	30.06	30.08	
Phosphorus....................	faint trace .	trace.	faint trace .
Sulphur	trace.	trace.	
Titanium	none.	none.	
Rock matter....................	2.74	2.58	
Metallic iron......	70.38	70.50	69.77

Deposit No. 1 is on lot 27 in concession 15 of Glamorgan. Deposit No. 2 is in the eastern part of Monmouth ; I do not know the number of the lot, but the two are ten miles apart and are taken from the solid lode, no float pieces. Deposit No. 3 was analyzed for iron and phosphorus only, and is situated twenty miles further east than No. 2. We have other deposits of similar ore in the north range ; there is one situated between the extreme east and No. 2 in the township of Cardiff, containing 68.27 of metallic iron. Following are analyses of samples from the south range :

Analyses of ores in south range.

——	1	2	3
Metallic iron..................	59.5	60.00	45.82
Phosphorus....................		.02	.02
Sulphur.............	.05	Trace.	

Victoria, Howland and Imperial mines.

No. 1 belongs to Mr. Shortiss and his associates, and is known as the Victoria mine. It was worked by our company at one time. The average ore would run from 58 to 61 per cent. ; but there was some as low as 48 and 50. No. 2, known as the Howland mine, is situated east of the Victoria mine in Snowdon township. There is one peculiarity about it which would apply almost as well to the Victoria mine, viz., the large amount of lime, 4.12 per cent., which it carries. It has also 2.72 of magnesia and .30 of alumina. All the sesubstances come in for fluxing, and answer very well for that purpose. The Imperial mine, No. 3, is also situated in the township of Snowdon. It yields a low grade ore, but one very free from impurities. I call it a hematite mine, but I think it will turn out to be more of a specular iron than a hematite.

Pine Lake mine.

"I think I should say a word about a very large deposit of titanic iron ore on lot 35 in the fourth concession of Glamorgan, known as Pine Lake mine. It has been explored by test pits at many different points which show a solid ledge half a mile in length by 100 to 200 feet in width. It forms a high ridge, and at one point crossed by a ravine there is an exposure of ore to a depth of 80 feet. It is a magnetic ore, containing 53½ per cent. of metallic iron, .017 of phosphorus and about 10 of titanium. This excess of titanium makes the ore useless according to present furnace practice, but recent experiments give good reason for hope that the titanium difficulty can be overcome with suitable flux. And it is well known that titanium in iron is not in itself objectionable ; on the contrary, it adds to the strength and ductility of iron. The Pine Lake mine however is the only one in the two parallel ranges of fifty miles in length which shows titanium in hurtful quantity. There is also only one mine in these ranges in which phosphorus is in excess of the Bessemar limit. Where ore is shown to exist at so many points along the two ranges, and visible by outcroppings in large quantity, I think there need be no fear for the supply."

Pusey.

ORES IN NORTHERN ONTARIO.

The principal area of the Archæan rocks of the Province is in the region north of the great lakes, lying between Ottawa river on the east and Lake-of-the-Woods on the west. There is good reason for believing that this territory is rich in minerals, and many valuable discoveries have already been made in it, although on account of its great extent it has been but very imperfectly explored. Iron ore has been discovered in numerous localities, east and west, but mostly in association with the Huronian rocks, and some of the deposits are known to be very large, and the quality of the ore is claimed to be very good. During recent years however there has been no inducement to explore the country for iron, and little progress has been made in our knowledge of its occurrence, saving in two or three localities beyond lake Superior.

Iron ores in the region north of the great lakes.

Iron island in lake Nipissing is composed of crystalline limestone interstratified with and cut across by trap. Small masses of specular iron ore, Mr. Murray stated in his report for 1854, are common to most of the rock in this island, but in the crystalline limestone there is a large display of it. For a breadth of about forty yards along the cliff on the east side the rock yields masses of ore of various sizes, sometimes in strings of an inch thick or upwards, and at other times in huge blocks of half a ton weight. The beach near this outcrop is strewed with masses of all sizes from several hundred pounds to small rounded pebbles not larger than marbles. Crystalline limestone also crops out on the west side of the island, which appears to correspond with that holding the iron ore on the east. The same minerals are found disseminated through the rock and strewed upon the beach. At the southwest point of the island the rock is again limestone, and a long beach running out from it to the westward is covered with boulders of specular iron ore. Iron ore also occurs at the southeast of the island, but not in such great abundance, and only in detached masses strewed upon the beach.[33]

Specular ore in lake Nipissing.

In the report of the survey for 1848-9 Mr. Alexander Murray refers to the discovery of a vein of specular iron ore in the La Cloche mountains along the north shore of Georgian bay, on the Wallace mine location, "cutting the strata in a north and south direction with a width of 15 feet." Specimens of the ore from this vein were presented to Mr. Murray by Mr. Bristol, but he states that he had not an opportunity of visiting the locality. On analysis by Dr. Sterry Hunt the ore was found to contain 68.6 per cent. of metallic iron. The lode, Mr. Murray says, would yield 20 tons of metallic iron per cubic fathom, or at a breadth of 12 feet 40 tons for every fathom forward by a fathom vertical.[34]

Specular ore in the La Cloche mountains.

Wallace mine location.

It is shown by more recent examination however that the vein is not so large as was reported to Mr. Murray. The report of the Mining Commission describes it as consisting of about 8 feet of banded ore and quartzite, the ore varying from crystalline to compact specular. "The bed or vein may be traced some 200 or 300 yards westward and is about two feet in width where last visible." Eastward it is covered by a mass of *debris*. Mr. Thomas Frood, who is part owner of the location, described the ore as of steel color, slightly magnetic, and part of it as red and very soft. "The vein is visible for about 200 yards; at the west end on the face it is about six inches wide;

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[33] Geological Survey of Canada, 1853-6, p. 123.

[34] Geological Survey of Canada, 1848-9 p. 45.

at the east end where the pit has been sunk, the width of the vein is about 8 feet. The depth of the pit is about 20 feet and the vein seems to increase in width and the ore to improve in quality as we go down.[35]

Other occurrences.

South of the Wallace mine location and three miles northwest of Killarney, on a peninsula of grayish Huronian quartzite, Dr. Bell says there is a promising deposit of magnetic ore.[36] Explorers also report a fine occurrence of iron ore from this peninsula westward towards La Cloche island and eastward into the township of Rutherford.

Specular ore near Echo lake.

In describing the geology of the Huronian formation in the vicinity of Echo lake, Mr. Murray states that specular iron ore was frequently observed both in the trap and in the sedimentary portion of the formation, occasionally arranged in thin, continuous layers between the strata for considerable distances, and at other times in small isolated masses irregularly distributed through the rock. The latter condition, he states, was especially observed in the quartzose conglomerates with blood-red jaspers, where indeed the iron ore appeared to constitute a characteristic mineral.[37] Mr. R. E. Baily described to the Mining Commission a deposit of specular ore which he had discovered about three and a half miles northeast of Echo lake, and which had a width of 15 or 20 feet. Openings had been made upon it at six or seven places by which it had been traced for about 1,400 feet. The ore was shown by analysis to contain 65 per cent. of metallic iron, and to be very free from phosphorus and sulphur. Other discoveries are also reported in the same region.

A hematite mine at Desert lake, in Coffin.

In the township of Coffin James Stobie developed a location in 1874, and worked it three or four years. The width of the vein, Mr. Stobie stated to the Mining Commission, was from two to eleven feet, and the ore could be traced for a length of two miles. It was a hematite ore of good quality, and for three seasons it was shipped to Detroit. The location is at Desert lake, ten miles northwest of Bruce mines.[38]

On the east coast of lake Superior.

In 1865 Mr. Macfarlane made an exploration of the east shore of lake Superior, where the formations are largely the same as in the northern peninsula of Michigan. He observes that as the great beds of red hematite which occur at Marquette belong to the Huronian series of rocks, it ought to be matter for congratulation that the same ore has been found to characterize the same rocks on the Canadian shore. Discoveries of hematite had been made at Batchawana bay and Gros Cap, and "although neither of these so far as yet opened can compare in richness with the Marquette deposits, it cannot be doubted that future explorations, if vigorously pursued, will quickly develop iron mines on the north shore equally remunerative as those on the American side." The Batchawana ore bed is about seven miles to the northwest of the village of that name. The ore is principally specular iron, the less compact hematite being comparatively rare. There is also an admixture of magnetite, and both ores in narrow bands are interbedded with smaller bands of dark red jasper. The thickness of the banded bed is not less than twenty feet, and in some places cannot be less than forty. The deposit on Gros Cap presents more promising features where it overlies a bed of greenstone slate, and seems to occupy a valley running northwestward between higher rocks. The total thickness of the ore-bearing bed is about sixty feet, but the upper part is very poor, containing merely finely-disseminated ore. Various other beds were observed in the same locality cropping out upon the lake shore.[39]

Batchawana ore bed.

Gros Cap deposit.

Dr. Bell visited Gros Cap eleven years afterwards, and refers in his report to two exposures of hematite on the southern part of the cape. One of these is fifteen or twenty feet of very impure purplish red hematite, interstratified with thin, drusy, gray, silicious beds, the band dipping south 30° west at an angle of 70°. The second is near the southwest extremity of the cape and had been worked several years previously. It is about twenty feet in thickness, consisting of thin and very distinct and regular ferruginous beds. "The best layers appear to be a sufficiently rich iron ore, but it is questionable whether the earthy beds do not form two large a proportion to make it profitable to mine the whole mass in order to obtain them."[40]

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[35] Report of the Commission, pp. 123 and 143.

[36] Geological Survey of Canada, 1876-7 p. 210

[37] Geological Survey of Canada, 1857, p. 24.

[38] Mining Commission's Report, p. 143.

[39] Geological Survey of Canada, 1863-6, pp. 129-31.

ORES NORTH AND WEST OF LAKE SUPERIOR.

North of lake Superior.

An exploration survey of the country north of lake Superior between the Nipigon and Michipicoten rivers was made by Robert Bell during the years 1869-70, and in his report reference is made to the occurrence of thick beds or veins of magnetic iron ore in massive crystalline granitoid rock of red orthoclase and black hornblende at the mouth of the Little Pic river. The ore occupies a horizontal position in a cliff, and the united thickness of three of the beds appears to be about ninety feet. One sample of this ore yielded 36 per cent. of metallic iron, and another from a different part of the deposit 46 per cent. A band of impure solid hematite ore was also found on the west point of the largest of the Slate islands, and a silicious slaty magnetic ore was found to occur as a band two feet in thickness on the portage at the west end of Little Long lake.[41] William Murdoch, civil engineer of Port Arthur, informed the Mining Commission that he had sold an interest in a very large deposit near Loon lake where there is said to be a million tons of ore in sight. On Ruby lake also he stated that there is a deposit of hematite which will go 65 per cent.[42]

Ores on Loon and Ruby lakes.

The Vermilion and Mesabi iron ranges of Minnesota extend into Ontario.

The two great iron ranges of Minnesota, the Vermilion and Mesabi, have been traced northeastward into Ontario. The Vermilion enters our Province at the eastern end of Hunter's island, and numerous outcroppings have been discovered on the range across that island.[43] Prospectors also report the appearance of ore at a number of places inland, and although careful exploration has not been made it is probable that the ore deposits on the Mattawan river are on the continuation of the Vermilion belt. In the report of the Mining Commission Michael O'Keefe of Tower, Minn., is credited with saying that he had explored Hunter's island north of Emerald lake and traced a deposit of iron ore a total distance of eight miles, the width of which varied from 50 to 300 feet. James Sheridan also informed the Commission that he had explored Ontario on the north side of Knife lake, on the east of Hunter's island, and took up an iron location there. He described the ore as a hard red hematite mixed with jasper, like the Vermilion, and lying between walls of diorite and chloritic slates. The deposit is 90 feet wide, and the bed can be traced for three miles along the strike. Assays of the ore showed it to run from 47 to 56 per cent. of iron, and Mr. Sheridan thought that it would average about 50 per cent.[44]

On Hunter's island and Knife lake.

Features of the Mesabi range.

The Mesabi range has been carefully explored during the last three years by Mr. H. N. Winchell of the Minnesota Geological Survey, and a valuable report by him has recently been published upon it. This range lies at the base of the Animikie formation, and has been traced northeastward into Ontario, crossing the boundary at Gunflint lake and curving around to the head of Thunder bay, east of Port Arthur. It is an iron-bearing belt over a large portion of its length, but the ore varies in richness, and in many stretches the range is lean or altogether barren, as indeed is the case with almost every known iron belt of considerable length. West of the Duluth and Iron Range Railway the ore is found under deposits of clay and gravel, and when uncovered it may be scooped out and loaded on to cars with a steam shovel, being almost of the consistence of fine sand. It is of the hematite variety and of different colors and shades of colors, red, blue and brown. East of the Iron Range Railway the ore beds are covered by strata of black slate, or of an eruptive rock called gabbro which was poured out over them like volcanic lava. The effect of this overflow of molten rock, in the opinion of Mr. Winchell, was to convert the hematite into a magnetic ore. In the northern part of the state, and on the Ontario side, the ore on this range is almost invariably magnetic as far as known; but possibly there are sections of it over which the gabbro did not extend. South of Gunflint lake, on the Minnesota side, mining operations have been carried on during the past year, and it is expected that ore will commence to be shipped this year to Fort William over the line of the Port Arthur, Duluth and Western Railway. The superintendent of the Barnum mine at Ishpeming, Mich., Mr. William Sedgwick, gave to the Mining Commission some information respecting ore deposits on this range on Gunflint and North lakes. On the north side of the first-named lake he stated that there is a rich magnetic ore suitable for Bessemer steel, the analysis of which gave 68 per cent. of iron, .028 per cent. of phosphorus, no sulphur, and very little silica. He satisfied himself that there was at least 25 feet in thickness of this ore, but how much more he did not wait to determine, lest some one might take advantage of his discovery and purchase the property from the Government before him He also obtained specimens from drift boulder and ledges of good quality ore at several other places on the north side of both lakes.[45]

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[40] Geological Survey of Canada, 1876-7, p. 220.

[41] Geological Survey of Canada, 1870-1, pp. 347-8.

[42] Report of the Commission, p. 144.

[43] "Hunter's island is interesting economically chiefly for the iron ores associated with jaspery beds which occur on its southeast side, and which are entirely analogous geologically to the famous iron ores of Vermilion lake at Tower, Minnesota." Geological Survey of Canada, 1888-9, p. 27A.

[44] Report of the Commission, pp. 125-6.

Ore on Gunflint and North lakes.

Grady.

Michael Grady of Kingston, an explorer, has given the following information to the Bureau respecting the iron ores in this region, on the Ontario side of the boundary:

Exploring on the Mattawan river.

"I am in the employ of the Kingston and Pembroke Mining Company as prospector. I have been prospecting on the Mattawan river. a tributary of the Kaministiquia, and also on Gunflint lake near the Minnesota boundary. I was there in company with Mr. Williams, P. L. S., of Kingston. We took up and explored seven locations on the Mattawan. These locations are situated about twelve miles southwesterly from Finmark station on the C.P.R. The ore we found there was a hard hematite. We explored the location called W 222, with the diamond drill which we had taken there the previous winter. We put down four holes to a depth of about 300 feet and found ore most of the way down. We had several assays made of it which averaged 50 per cent. metallic iron, and contained no objectionable impurities such as sulphur, phosphorus or titanium.

"The hill in which the ore occurs rises to a height of 100 or 150 feet above the level of the surrounding country. The ore crops out in the direction of the strike of the rocks, which is about north 70° east. The dip is nearly vertical. The next best location is W223, adjoining the above-mentioned on the west. The ore appears to be more solid here and has a somewhat slaty structure. The hill in which it occurs is about the same elevation as that on W222. The strike and dip are also the same on both locations. The country rock on the south side of the ore outcrops is greenstone, and on the north side a chloritic schist which sometimes partakes of the nature of a conglomerate. We did not use the diamond drill on W223, but put down three pits to a depth of eight or ten feet. Samples of the ore obtained assayed over 60 per cent. metallic iron, with no objectionable impurities; good Bessemer ore. We did not find any outcrops of ore west of this location.

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[45] Report of the Commission, p. 126.

Grady.

"As regards to the extent of these ore outcrops, I should say that on location W222 the deposit is about one-fourth of a mile in length and about 200 feet in the widest part, narrowing to about 50 or 60 feet at its eastern and western extremities. On location W223 the outcrop is nearly half a mile in length. In one place it is 400 feet wide. It narrows and becomes split up towards the southwest end.

Extent of the ore bodies.

"At Gunflint lake the ore deposits are not so well defined. They are in nearly horizontal beds. We found some very good ore there. Assays gave about 60 per cent. iron with no objectionable impurities. We did no work there, except sinking a few test pits through the soil down to the ore-bed. The ore is different from the Mattawan, being magnetic. I should say that the Gunflint and Mattawan ranges are about 40 miles apart, the latter being northwest of the former.

Horizontal beds of ore at Gunflint lake.

"We have not done anything along the Kingston & Pembroke road this year. The mines are all idle. I have not done any prospecting there either. At the present prices of iron ore we can't work these mines and ship the ore to the States in the face of the McKinley tariff. If the duty was off we could work them at a fair profit. There are no iron mines down here being worked this year that I know of."

David Williams of Kingston, a Provincial Land Surveyor, has been engaged in exploring for minerals and surveying mining locations in the same region for three years, and the following statement has been furnished to the Bureau by him:

Williams.

"I am a Provincial Land Surveyor and reside in Kingston. I have been engaged during the last three years in mining surveys and explorations in the regions west of Port Arthur in the Thunder Bay district. I have made surveys and explorations at Gunflint lake along the international boundary, and had some test pits sunk on locations R311 and R317, where we found some very promising beds of ore. Assays gave about 60 per cent. metallic iron, with no sulphur, phosphorus or titanium. The ore lies in nearly horizontal beds, in what is sometimes called blanket ore. One deposit extends from location R205 westerly across R315 and partly across R317, It is from 50 to 150 feet wide. We did not do any blasting, so that I cannot say much about the depth or thickness of the bed, but its superficial area is so great that it will in any case yield a large amount of ore.

Locations near the international boundary, at Gunflint lake.

"Another deposit lies along the northern border of location R311. It crops out of the side of a high hill, where it occurs in layers of varying thickness, alternating with thin layers of shale and rusty quartzites. There is every indication of a large body of ore. It can be traced along the side of the hill for nearly half a mile. I have since traced this ore formation northeasterly to near the southern boundary of the township of Strange, and have discovered a number of localities which give strong indications of the presence of valuable ore beds. There is no doubt but that this range is a northeastern extension of the celebrated Mesabi range in northeastern Minnesota.

"In the fall of 1890 I examined what is now called the Mattawan iron range. Mr. James Hammond of Fort William had prospected the range during the previous summer and had made some important discoveries. I reported very favorably and Mr. Hammond was joined by Messers. Folger Bros. of Kingston, and together they took up 17 locations along the range. Since then we have done some development work in different places on the property. The work on W222 and W223 has been described in Mr. Grady's evidence. During the last year Mr. Hammond has sunk a shaft to the depth of about 60 feet on location W211. This locality presents some very interesting features. One formation is about 200 feet wide. The surface rock

Locations on the Mattawan iron range.

Williams.

consists largely of banded jasper and iron all broken up into small angular blocks, which a short distance below the surface are cemented together with iron, forming a breccia with the iron filling the spaces between the angular blocks and forming part of the blocks themselves. The jasper in the ore steadily diminishes with the depth, and we have good reason to believe that it will work out altogether a little deeper down. The ore is a fine-grained specular, very pure in spots. Large pieces could be obtained that would carry 65 to 68 per cent. of iron.

Exploratory work at Middle Falls, on the Mattawan.

"Two or three excavations were also made on location W 219, near what is called the Middle Falls on the Mattawan river. The ore formation is here about 200 feet high. The workable ore bed is about 60 feet wide and can be traced a long distance on the line of strike. It is thrown up into a hill about 200 feet wide. The excavations were in the form of cross-cuts into the hill, and they exposed a large fine body of ore. I think the assays gave about 54 per cent. good Bessemer ore. The Mattawan range can be traced eastward beyond the Kaministiquia station of the C. P. R.; but in this direction the ore becomes very lean, and large belts of jasper seem in some places to occupy the ore horizon. The ore belt seems to follow the axis of a synclinal, and I think that the folding of the ore bed upon itself will account for its great width in some places. On location W 223 it is 400 feet wide. It is by far the largest body of ore I have ever seen, and I believe it is one of the largest on record."

Conmee.

James Conmee, M.P.P., has furnished the Bureau the following information on the iron ore occurrences in the same localities:

Object of the Port Arthur, Duluth and Western Railway.

"I have been engaged in building the Port Arthur, Duluth and Western Railway. The line in Ontario is now completed, the distance being 87 miles to the international boundary at the southwest end of Gunflint lake. Our object was to reach the iron ore on the American side as well as the Canadian. For this purpose we have constructed six miles of road on the American side. We have a contract with the Gunflint Iron Company by which they undertake to ship 1,000,000 tons of iron ore at the rate of 100,000 tons a year. I have seen the deposit of iron ore at Gunflint lake, and it appears to be an extensive one. The outcrop, which occurs along the base of a high ridge of rock, varies in width from 10 feet at some points to 100 feet at others. I stepped along the outcrop, which was stripped in places, and found the length to be about 3,000 feet. I think there is a large body of ore there, and there is more further on; a mile beyond this place a diamond drill was set at work and it struck ore running in the same direction. I understand that pretty extensive tests have been made with the diamond drill, and a large body of magnetic ore is said to have been found I am told the ore assays from 63 to 67½ per cent. of metallic iron. It is almost entirely free from phosphorus, and contains very little titanium; it is claimed to be a first-class Bessemer ore. The ore will be sent over our line in bond, and then shipped on to Cleveland or some other place. I have reason to believe that the same range of ore crosses the boundary line into Ontario. It comes across right along our line of railway, at the Narrows between Magnetic and Gunflint lakes; I have seen several outcrops there myself. The greater part of the land on which these deposits occur is owned by Caldwell & Co. of Lanark, and Folger Bros. of Kingston. They had Mr. Williams there, and Mr. Michael Grady, both mining experts, who reported on the property and claimed to have found a very large body of ore. They stripped the ore in places, sunk several test pits, and had a number of men working there during the whole of the summer of 1891. They have not mined the ore at all; but they say that it is the same ore in appearance and quality as the American ore. The range has been traced into Ontario in a northeasterly direction as far as the vicinity of Whitefish lake, a distance of 35 miles far-

Ore bodies in the vicinity of Gunflint lake.

Tracing the range into Ontario.

ther; there are outcrops of ore all along, in several places. It has not been traced beyond Whitefish lake. The Gunflint range, both on the Ontario and American sides, is a continuation of the Mesabi range in Minnesota. This at least is the general opinion of geologists. Mr. Winchell, assistant state geologist of Minnesota, was over there a few weeks ago, and he told me it was a continuation of the Mesabi range. The only difference is that so far as it has been developed the ore at this end is a hard ore, while at the other it is a soft ore in places.

Conmee.

"There is another range of iron ore about four miles north of the one I have been speaking about, on the Ontario side, just lately discovered. I do not know much about its extent, but the ore is of very fine quality; it assayed 65½ per cent. of iron and carried also a good percentage of manganese. This range is near Sand lake, four miles from our railway. The deposit has been found to be a large one. A pit has been sunk about 15 feet, and as far as the pit has shown up the vein it seems to be very much decomposed. They had not got down to what they considered the solid ore. The manganese appears to be dispersed among the ore, but it also occurs in pockets; they have taken out small quantities of manganese almost pure.

A parallel range near Sand lake, showing rich ore.

"I also know of the occurrence of iron ore on the Mattawan river; I have been there. The principal owners are the Folger Brothers of Kingston. I own a location there myself, and Mr. Pumpelly and his friends own a very large block of land there. They have surveyed and explored it, but I do not think they are interested with Folger Bros. The latter have tested their locations with a diamond drill; I am not aware that others have done so. I believe the ore there to be very extensive; the vein is three hundred feet wide in places, and at no place that I saw was it less than 75 feet wide. The ore crops out at the surface in very many places, and is quite easily traced for 20 miles, running in a southwesterly and northeasterly direction. It is mostly hematite; all that I saw was hematite. It is apparently not quite so rich an ore as the Gunflint or Atik-okan ores on the surface, from which assays show 45 to 55 per cent. of iron; but where the prospectors bored with a diamond drill they have got very much better results; they have got as high as 62 per cent. according to my information.

The Mattawan range.

"There are outcroppings of iron ore farther north, but not of the same permanent character. The range crosses the Kaministiquia river about 20 miles west of Port Arthur, above the falls. This is not the range which extends into the townships of Ware and Gorham. The latter is a hematite ore, what I would call an iron slate. It occurs in a sort of slaty formation, and I should take it to go about 30 or 35 per cent of iron."

Other ore ranges farther north.

The following paragraph on shows of iron ore on the Kaministiquia river is taken from Dr. Bell's report to the Director of the Geological Survey:

Ore shows on the Kaministiquia river banded with jasper.

"In the hills on the left side of the Kaministiquia river a finely-banded rock made up of jasper and magnetic iron occurs at the distance of one mile southeast of the junction of the Mattawan. The alternating beds are usually not more than from one-half inch to two inches thick, and present a very striking contrast; the jasper being brown or bright red, while the magnetic iron is black, finely granular and glistening. The beds are somewhat contorted, but their general strike appears to be about east and west. On the west side of the Kaministiquia river, at about a mile and a half below the Mattawan, the same ribboned jasper and iron ore rock occurs, associated with black arenaceous layers, semi-translucent banded chert, approaching chalcedony, and dark fine-grained hard ribboned argillite or felsite, having a conchoidal fracture. These strata are considerably contorted and dip at high angles, but their general course appears to be northwestward."[46]

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[46] Geological Survey of Canada, 1866-9, p. 330.

Red hematite on Arrow lake, and slaty iron on Nipigon lake.

Dr. Bell also mentions the occurrence of iron ore at many other points west and north of lake Superior, specimens of which were shown to him, among them being pure red hematite from Arrow lake and a slaty iron ore from the east side of lake Nipigon. The latter was found to contain 51.51 per cent. of peroxide of iron (= 36.06 metallic iron), traces of manganese, .076 per cent. phosphoric acid and 8 of alumina.

THE ATIK-OKAN IRON RANGE.

A belt 15 miles in length.

Going farther west another extensive range of magnetic ore is found on Sabawe lake and Atik-okan river, which has been traced a distance of 15 miles westerly on the course of the river to its junction with the Seine. Large deposits have also been discovered down in the valley of the Seine, but some analyses show these ores to contain titanium. Referring to the deposit on the Atik-okan or Antler river in the Mining Commission's report, Dr. Bell describes it as a large body of magnetite of fine quality. There are three beds in the widest part, each about fifty feet in width, separated from each other by narrow bands of rock running with the general course of the belt to which they belong. "The deposit," Dr. Bell wrote, "shows workable quantities of ore at intervals for about three miles, and is traceable for about five miles." But more recent explorations show that outcroppings occur over a distance of fifteen miles. Dr. Bell also refers to another rich deposit near the mouth of the Seine river, and one of lower grade ore at a straggling lake southeast of Wabigoon lake.[47]

Conmee.

Mr. Conmee, M.P.P., who has been over the Atik-okan range, has supplied the following information respecting the shows of iron ore upon it:

"I have been on the Atik-okan range and have examined the iron ore there. This is the greatest deposit of iron ore I ever saw. There is a vein varying from 40 to 150 feet in width, and rising up to a height of 100 to 150 feet in places, and extending, so far as my observation goes, for about 25 miles. I have followed it for that distance myself, and it appears to be a continuous outcrop all the way, of pretty uniform width, but varying in height, dipping in places and rising again. It has been tested with a diamond drill on several locations by Thomas Marks & Co.; they have tested on locations of their own, and on those belonging to some Americans. The ore is magnetic On the surface it is a little decomposed, but it is all ore: there is very little mixture with it. It is said to carry a considerable percentage of sulphur, which is its only drawback, so far as I know. It runs up to 65 and 67 per cent. of metallic iron, and is of this uniform richness. It is a very rich ore.

Tracing the length of the range.

"This range is about 80 miles from any present railway; the northeast end of the range would be about 50 miles from the Canadian Pacific, at Fire steel river, or a little west of that point. The property could not be worked until a line of railway was constructed. The line of the Ontario and Rainy River Railway runs right across the southwest end of the range. This line has been located.

Want of railway communication.

"There are no facilities for getting out the ore from the Mattawan range. There are portions of the vein which occur within about 8 miles of the C.P.R., near the Kaministiquia river. The deposit gets much richer farther west, and couldbe tapped either from the Port Arthur, Duluth and Western or the C.P.R. by a line of railway some 30 miles in length. The other deposits of ore are within convenient distance of the former railway."

McKellar.

The following description of the Atik-okan iron range was written by Peter McKellar and published by the Bureau of Industries, 1886, p. 409:

"This great magnetic iron deposit, on locations 10 E, 11 E and 12 E on

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[47] Report of the Commission, p. 22.

McKellar.

Locations 10 E 11 E and 12 E described.

Extent of the ore lode on Iron mountain.

Atik-okan river, lies about thirty miles southwest of Bridge River station, dian Pacific Railway, which station is about ninety miles west of Fort iam. The ore lode, which is divided into two or three branches in places, Iron mountain, has been traced by the outcrops for a distance of nearly miles along the strike of the formation, with which it appears to conform p and strike. The formation consists of the Huronian green chloritic dioritic schists, with a dip nearly vertical, or about 80° to 85° to the on northward. Herein I will describe Iron mountain only, the middle on of the above run of ore, which is largely exposed and of which the nination was well and carefully made. The ore lode aggregates a thick- of 100 to 125 feet, divided into two and in places three veins by a belt or of the green schist 20 to 60 feet in thickness. This with the associated s forms a mountain range nearly a mile in length and 300 to 400 feet in h, and that rises to elevations of 60 to 125 feet above the surrounding ; it therefore presents unusually favorable natural advantages for turn- ut a large quantity of ore in a short time. The ore is remarkably uni- in grade or percentage, and is described as follows by Professor Chapman niversity College, Toronto, the leading authority on iron ores in Canada.

Analysis.

'The sample consists of fine-grained, comparatively soft black magnetic ore. hown by analysis the ore is exceedingly rich in metal, holding 70 per metallic iron, with very little silicious rock matter, very small amounts lphur and phosphorus, and no trace of titanium. Its specific gravity ls 4.93; hence the weight per cubic foot is equivalent to 307¼ pounds. r as regards composition and physicial characters, a better ore could not otained.'

Ferrous oxide	29.98	=metallic iron......23.32	=70.06.
Ferric oxide	36.77	= " 46.74	
Titanic acid	None.		
Sulphur	0.06	(strictly 0.062).	
Phosphorus	0.02	(strictly 0.025).	
Alumina	0.67		
Silica	2.43		
	99.93		

After the above sample test the deposit was systematically tested by rican iron experts, who pronounced it first-class in every respect. The was closely sampled at several points and different samplings analysed, of which showed titanium or sulphur. The percentage of metal was being 63 to 70, and the phosphorus low, or 0.011 to 0.035.

The regularity of the stratification of the ore and schists along the sur- shows that the ore deposit is not superficial or liable to give out quickly ward any more than it does along the surface horizontally. The lode change in size a little either way in sinking 400 to 500 feet; but here ll be more likely to be in the direction of an increase rather than that of rease on account of the dip of the outside walls along the middle portion on mountain.

Estimate of ore in Iron mountain.

After a thorough surface examination of the Iron mountain lode, I ate the quantity of good ore to exceed 2,000,000 tons for the 100 feet of , or 10,000,000 for 500 feet. I doubt if there is any other known deposit in either Canada or the American great iron districts of lake rior that gives a more valuable show in regard to quality, quantity and atural advantages presented for mining.

The difficulty in the way of its present development is the distance to a ay or to navigable water. To make the ore available would necessitate uilding of a railway branch thirty miles in length to connect with the dian Pacific, and negotiations are in progress that promise to result is ommencement of the work at no distant date. So much wealth as ir n to exist here and the great trade its opening would create in the ict are sure to cause the building of this branch before long.

McKellar.

"Besides the iron trade, the building of the proposed branch would open up other valuable industries in the locality. The rock formation consists largely of metamorphic schists associated with granite, a formation highly favorable for the bearing of metals. Even now, although the locality is but slightly known to the mineral explorer, two very promising gold veins (Partridge Lake and Osinawe lake veins) have been discovered within a radius of six miles of Iron mountain. There are some good tracts of timber lands in the locality; also farming lands, such as that in the grand valley of Seine river along which the proposed railway branch would run for the greater portion of its length. The Huronian and Animikie formations, the iron bearing rocks of the American iron districts on lake Superior, are largely developed in Canadian territory north of lake Superior and the American boundary."

Wiley.

The following statement has been furnished by Harold A. Wiley of Port Arthur, whose firm is interested in the Atik-okan range.

Locations west of lake Sabawe.

"I reside at Port Arthur and am a member of the firm of Thomas Mark & Co., merchants, forwarders and shipowners. For the last five years I have been dealing to some extent in mining lands, and I have also prospected in various parts of the district. Five years ago I became aware of the existence of iron ore on the Atik-okan river west of lake Sabawe, through the report of Indians. Two years previous to this Messrs. McKellar and Graham had discovered and taken up locations east of the lake which were reported to contain very large deposits of magnetic ore. In the summer of 1887 we sent out a party of explorers who continued in the field for several months and reported to us a discovery of ore west of the lake which showed outcroppings five miles in length. This is a continuation of the McKellar range, and the ore is of the same character. It is a series of low hills sixty to eighty feet in height, with intervals of low ground, the ore occurring in lens-shaped masses varying in width from ten to forty feet. The lenses are of various lengths, from one to ten chains. We carried on explorations with a diamond drill for six months during the season of 1891, having taken the drill in from Savanne station on the C.P.R. during the previous winter. Sixteen holes in all were bored, eight on our own properties (R400, 401 and 402) and eight on another location adjoining ours on the west (X212). On R400 the total extent of drilling was 340 feet; on R401, 792 feet; and on X212, 1,010 feet. In one of the vertical borings ore was found to a depth of 265 feet (this being the length of the drill rods) which averaged 64 per cent. of iron and showed only a trace of phosphorus. Some of the cores analyzed 68 per cent. iron. I am fully satisfied with the quantity and quality of the ore on the Atik-okan range. An eminent American geologist who examined it carefully assured me that upon two locations alone the quantity in sight was not less than 1,500,000 tons, and the range is at least thirteen miles in length."

Diamond drill explorations.

Two years ago last October W. W. Russell, P.L.S., of Port Arthur furnished at my request the information contained in the following paper on the Atik-okan range:

Russell.

"During the past summer the extensive and rich deposits of magnetite on the Atik-okan river, about one hundred miles west of Port Arthur, have attracted much notice from iron mining men, especially Americans, and have been visited by many prominent parties. The extent and high grade of the outcroppings have excited surprise invariably, though some expressed disapointment at finding no development work done.

First discovery of iron ore on the Atik-okan river.

"Some five years ago the first discovery of magnetite in this range was made, and a tract taken up by Messrs. Graham & McKellar. The property was shortly afterwards examined by Mr. D. H. Bacon (now superintendent of the Minnesota Iron Co.), and on his report bonded for a long term to a Cleveland party represented by Major Pickands. No active operations have

Russell.

oegun. The discovery of the iron did not attract general notice in any ntil the finding last fall of another equally extensive and rich deposit, l miles further west on the same range. The result of this was the ıg of numerous exploring parties this summer, and the discovery of ther outcrops of the same ore further westward, until now these rich ts have been traced by outcrops for a length of sixteen miles along the

Nothing more than a superficial examination of the deposits has been in the way of a few surface cross-cuts, and an occasional shot to secure thered samples ; but in many places the ore outcrops boldly, showing ying width of from 10 to 50 feet.

Before describing these outcrops or surface showings more minutely, I efer to the geological occurrence of the deposits. They occur as beds ıronian hornblendic and chloritic schists, which are nearly vertical, a dip of 86 degrees north, and a strike of north 75 degrees east. The e showings indicate that there are several of these beds, the intervening aaving a width of from five to thirty feet. Whether these beds will at a depth or maintain their separate identity, is a problem for develop- work to decide. The Huronian belt has an average width of eight and rests conformably in the folds of the Laurentian rocks, so we may ne its depth (and that of the interbedded magnetite) to be very con- ole, practically unlimited.

Geological occurrence of the deposits.

The McKellar-Graham property is the most easterly on the range, and its onspicuous outcrops occur on the summit and both faces of a bluffy ridge g nearly east and west 100 feet above the level of the Atik-okan river. H. Bacon sampled the surface showing here, taking samples at three- ıtervals ; and for an aggregate width of 80 feet these samples gave 63½ ent. metallic iron, without more than a trace of titanic acid or phos- , and little more than a trace of sulphur. The outcrops here showed oeds of ore.

The McKellar Graham location, east of Sabawe lake.

mmediately west of the McKellar-Graham property is Sabawe lake, a of water three miles in length. For some distance west of the lake, in urse of the iron belt, a considerable depth of soil covers everything ; tends to location R400, on which and R401 other outcrops occur very to those on the McKellar-Graham property. A similar ridge traverses locations, and in many places, especially on the southern exposure, is very steep, large outcrops occur. Having closely examined these veral locations adjoining them on the west, I can speak more definitely m than of others where my inspection was more cursory ; and it may vell to state here that the ore throughout this range varies but slightly racter or grade ; it is virtually identical throughout, though in some where greatly exposed to atmospheric action it is, of course, leaner. ation R400, where a natural exposure of ore some twenty feet in width , a large number of samples taken at random gave from 66 to 68½ per netallic iron. On the location west of this, R401, a surface cross-cut ade this summer which showed 46 feet in width of ore ; the full width ot ascertained, as the cut was abandoned on account of the depth of ing soil and large boulders. Some of the ore from this cut, when pro- by deep soil, gave as high as 71 per cent metallic iron.

The range west of Sabawe lake.

A little more than half a mile west of this the ore again outcrops on the face of a ridge about fifty feet in height, the intervening ground being samples from here gave 65 per cent. Half a mile further west a short dug in the low ground showed rich ore at a depth of only three feet ; empt was made to uncover the width of the deposit, the sole object to locate it. A mile beyond this numerous showings are found along and south face of a ridge about 100 feet high ; the surface showings are very extensive, and the ore of the same high grade, 66 to 68 per

Tracing the range westward

Russell.

cent. For nearly three miles beyond this the ground in the line of the deposits is very low, and no attempt to locate the ore by test pits etc., has been made. As the ground rises, the ore again outcrops and shows at the crossing of the Atik-okan river, which is very rapid at this point. Beyond this I have made no personal examination, but have been informed by several who have been over the ground that about a mile and a half west there is another extensive outcrop on a high ridge similar to those already referred to. The country is very low and swampy for some miles, and no further discoveries have been made—or perhaps I should say made public.

"Although no development whatever has been done, the surface showings alone indicate the presence of an enormous amount of iron, which is uniformly free from injurious elements, and of an astonishingly high grade, and I am of opinion that much of the leaner silicious ore which is now ignored in sampling will at a depth become a good marketable ore. Many of the natural outcrops are on the south slopes of the ridges, and are much weathered and oxidised, resulting, of course, in the impoverishment of the ore.

Railway communication.

"To bring the Atik-okan ores to a market, a railway from 30 to 50 miles in length will have to be built from near Carlstadt station on the Canadian Pacific Railway to and along the Atik-okan river. An examination of the route was made by the Canadian Pacific Railway company last fall, and their engineer reported it a very easy one, estimating the cost of grading at not over $2,000 per mile for four-fifths of the distance, the balance being medium work only, to cost say $10,000 per mile. The company are not disposed to build the road unless a reasonable amount of freight is guaranteed, but are willing to equip and operate the road when built if desired, and to facilitate the successful operation of the mines by cheap freight rates, etc. There is no local traffic for the railway throughout this section, and it is plainly to the interest of the company to promote to the utmost any undertaking that might lead to making this part of the line a remunerative one through local traffic. That they are fully alive to this is very evident in all intercourse on the subject with the chief officials of the company.

Market for the ores.

"With regard to the market for these ores, and the cost of delivering them thereat: Mining will cost from 75 cents to $1 per ton, say $1 as an outside estimate. Railroad freight to Port Arthur or Fort William, $1 per ton. Lake freight to either of the principal ore ports on lake Erie, Cleveland or Ashtabula, may be taken as the same as that from Ashland or Two Harbors, the shipping ports of the Gogebic and Vermilion districts. The rate last year and during the present season has been about $1.25 per gross ton, and there is no reason to think this will be exceeded in the future, considering the continual increase in numbers and tonnage of vessels built on the lakes. Shipping charges, insurance, etc., may be taken at 30 cents per ton; duty going into the United States, 75 cents per ton. This will give the total cost, delivered at a lake Erie port, of $4.30 per ton. The present value of a high grade Bessemer ore, such as this under consideration, delivered on the docks at Cleveland or Ashtabula, is $6 per ton, which would leave a net profit of $1.70 per ton.

Shipments.

"The total lake shipments of iron ore amounted in 1888 to 4,700,000 tons, in 1889 to 7,300,000 tons, and up to and including 1st October of the current year, 6,480,000 tons. If the shipments for the balance of the season only equal those of the same part of last year, the total for 1890 will be about 8,500,000 tons.

"The Dominion Government gives a bonus of $2 for every ton of pig iron manufactured in Canada, and a portion of the Atik-okan ores might be profitably treated at Port Arthur or Fort William, where other ores for mixing, flux and fuel can be brought at low rates. Coal is carried here from lake Erie ports at from 40 to 50 cents per ton, and coke from 80 cents to $1.

Russell.

There is no duty on anthracite coal, and coke also is admitted free for smelting purposes.

"I append hereto a number of analyses of the Atik-okan ore from different parts of the range, and also a plan showing the locality, etc.

Analyses of samples of ore taken from the McKellar-Graham locations.

	1	2	3	4
Silica	6.60	7.30	5.89	2.43
Alumina	1.09	1.80	.98	0.67
Ferrous oxide	none	none	none	23.32
Ferric oxide	87.66	86.90	88.36	46.74
Manganesic	trace	trace	trace	
Calcic	1.28	0.90	1.40	
Magnesia	0.75	0.60	0.75	
Phosphoric acid	.0079	0.069	0.025	
Titanic	none	none	none	none
Total	94.46	97.57	97.41	none
Metallic iron	63.47	62.84	63.97	70.06

The first three are averages from the three beds sampled by D. H. Bacon, of the Vermilion mines in Minnesota, and the last is a single specimen by Prof. Chapman of Toronto.

Samples taken by W. W. Russell from locations B400 and B401 :

	1	2	3
Metallic iron	68.50	65.90	65.702
Silica	2.90	5.80	4.20
Phosphorus	0.015	0.001	0.003
Sulphur	0.052	0.16	not specified
Titanic acid	none	none	none

Assays by Sharon Iron Works, Pa., of samples furnished by Capt. M. N. Garland from property marked "Garland locations :"

Metallic iron	68.75
Silica	1.41
Phosphorus	0.006
Sulphur	0.185

Assays of Atik-okan ore by Dr. Hoffman, assayer of the Geological Survey of Canada :

1. Magnetite from R402 :	
Metallic iron	68.579
Titanium	none
2. Magnetite, R400 :	
Metallic iron	68.027
Titanium	none
3. Magnetite from R403 :	
Metallic iron	64.551
Titanium	none
4. Magnetite from line between mining locations 10E and 11E, collected by Smith :	
Metallic iron	65.710
Titanium	none

Smith.

Henry Lloyd Smith of Newport, Rhode Island, who with Raphael Pumpelly has taken up several locations in this part of the Province, has given to the Bureau the following description :

Exploring for iron ore in Ontario, on the Atik-okan range.

"I am a mining engineer, living in Newport, Rhode Island. I have been on the Geological Survey of the United States for five years, and have spent two seasons, or practically two years, exploring for iron ore in western Algoma, chiefly northwest of Port Arthur. My explorations have been

Smith.

wholly for iron ore. I spent several weeks on the Atik-okan river, where iron ore occurs in irregular lenses in greenstone, both walls, so far as we know, being greenstone. The ore occurs in a single range; that is, the ore bodies are found within a distance across the formation of 300 feet or less. The range is found both north and south of the river, which flows parallel to it, and crosses it several times in the course of 12 or 15 miles. The exposures of ore in some instances rise above the level of the country, and are some 80 to 100 feet above the river in places. On the locations belonging to Mr. Wiley and Mr. Marks of Port Arthur, on the north bank of the river, the ore is some 70 or 80 feet above the water. The ore of course is not continuous for the entire length of the range. On this property I do not think there is a single lens of ore that can be traced for more than 200 to 250 feet. There are considerable intervals of barren rock, more or less ferruginous. The limit between the ore and the rock is not so much a geological as a commercial one; that is, the ore gradually merges into the greenstone. In the middle of the lens you have a pretty pure magnetite, then, as the edges of the lens are approached, there is a greater or less mixture of rock, then gradually more rock comes in and less ore, until finally it passes altogether into rock. The physical characteristics of the ore are those belonging to magnetite. We have had extensive analyses made of it, but I do not bear in mind the figures; so far as I remember, the highest result we got was about 68 per cent. of metallic iron, which was not from a picked sample at all, but taken at intervals from a body of the ore 18 feet in thickness, and represented the same very fairly. It was a beautiful clean ore. The general character of the ore throughout the range is that of a fairly clean ore. I am interested in the property there along with other gentlemen. We have a location about a mile in length, containing about 160 acres. So far as we can see there is a large body of ore there. but it is impossible to speak definitely as to its extent.

On Steep Rock lake.

"Besides the Atik-okan river I have been on the Steep Rock lake, which is several miles west of the Marks and Wiley locations. The iron formation there overlies limestone. There is no body of clean ore exposed, but I do not think there is any question about iron ore being there. There are fragments of iron ore in the glacial drift along certain parts of the shore of the lake. The bodies of the ore there are probably under the waters of the lake, which are very deep, and I doubt if they have any commercial value.

On the Mattawan river.

"I have also explored along the Mattawan river, where we find very hard red hematite ore banded with jasper. It has not yet been found in any commercial bodies; iron formation alone has been found there, consisting of jasper banded with hard hematite, in which one would naturally look for bodies of ore. The formation is one very similar to the one in northeastern Minnesota. There is a large amount of this ferruginous material, but as yet no ore bodies have been found. We did no exploration with the diamond drill there. I understand that some gentlemen from Kingston have done some exploration with the drill there, but I do not know anything about the results they got. I have not been over this iron-bearing formation along the Mattawan for more than four or five miles. I have found it to be practically continuous for this distance, and I have no doubt that it extends considerably further. It is very hard to say whether the range is a wide one or not. It is probable that the iron formation is folded into several parallel troughs.

On Gunflint lake.

"I have not explored along Gunflint lake; I have simply taken a trip to that district. I did not see any ore bodies there. There is a very good-looking jasper in that section, and I think a great deal more of it since the discovery of the Mesabi range than I did when I went over it. It belongs in nearly the same geological horizon as the Mesabi ores, being near the base of the Animikie series.

Smith.

"I have been on the Mesabi range; the iron ore occurs not far above the base of the Animikie. The section shows that there is a time-break between the Animikie and the rocks beneath, which in some places are granite and in others green schists, that may be lower Huronian. Upon these the Animikie beds lie nearly flat, with a slight dip to the south. The lowest part of the Animikie is a quartzite, the thickness of which I do not know. The upper part of this quartzite becomes ferruginous and passes into ferruginous chert, which is the member containing the ore. Here and there are local concentrations of clean ore, some of which are of enormous dimensions. The great point in favor of the explorer on the Mesabi range is that the ore bodies lie flat, or at a less inclination than in any other portion of the iron districts of lake Superior. In the other iron districts these lenses are more nearly vertical, and you get simply the thickness exposed on the surface. On the Mesabi range they lie on their broad face, and you have the largest dimensions of the lens parallel to the surface. The chances of hitting any ore body that may exist on any property in exploration are thus enormously increased. In some parts of the Mesabi range the ore is not solid, but granular, of the consistence of sand; in other parts it is quite hard.

The Mesabi range.

Its extension into Ontario.

"I understand that the range is being worked near Gunflint lake, on the American side, but I have not seen it. There is no doubt whatever that rocks similar to those constituting the Mesabi range extend northeastward into Ontario; they come as far eastward as Loon lake, where they seem to be cut off by the Keweenawan series.

"I have not seen any large bodies of ore in the townships of Ware and Gorham. There are possibilities that ore may be found in these townships in quantities, but I do not regard the chances as very good.

ORES NORTH OF THE HEIGHT OF LAND.

Spathic ore on the Mattagami river.

In the report of the Geological Survey for 1875-6, Dr. Bell gives an account of a large deposit of iron ore in the Devonian formation on the Mattagami river, in the vicinity of the Grand Rapids, latitude 50.30° north and longitude 82° west. "Its position is on the northwest side of the river, at the foot of the rapids. It runs along the foot of the cliff for a distance of upwards of three hundred yards, almost continuously, with an exposed breadth of twenty to twenty-five yards. The highest points rise about fifteen feet above the level of the river. The surface is mottled, reddish-yellow and brown, and has a rough, spongy or lumpy appearance, like that of a great mass of bog ore. At the surface, and sometimes to a depth of several inches, it is a compact brown hematite, occasionally in botryoidal crusts, with a radiating columnar structure; but deeper down it is a dark-gray compact, very finely crystalline spathic ore, apparently of a pure quality. The brown hematite evidently results from the conversion of the carbonate. The former yields, according to the analysis of Mr. Hoffman, 52.42 per cent. of metallic iron, while the latter shows a very small amount of insoluble matter; indeed there is, chemically, little room for impurities, since it gives rise to so rich a brown hematite. The geological relations of this singular deposit are puzzling; it may be of newer date than the limestone gorge in which it occurs. The adjacent overlooking wall of soft earthy limestone is worn into vertical caverns, with fluted and rounded walls, like the sides of great pot-holes. They are sometimes partially lined with a thin coating of a highly ferruginous carbonate. The iron ore was nowhere seen quite in contact with the rock."[48]

Borron's explorations on the Hudson Bay slope.

Mr. E. B. Borron has been employed for several years by the Ontario Government exploring the Hudson Bay slope, and it is his opinion that iron ores are to be found there in inexhaustible quantity. In his evidence before the Mining Commission he stated that, as far as yet discovered, these

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[48] Geological Survey of Canada, 1875-6, p. 321.

Varieties of iron ores reported by him.

ores are chiefly carbonate of iron associated with limestone; rich brown hematite ore, resulting, as would appear, from the decomposition of the carbonate; bog-iron ores, magnetic ore and specular ore. The carbonate, brown hematite and bog ores, Mr. Borron says, doubtless exist in very large quantities. Magnetic ore has been found in places near the height of land, and probably in considerable quantity, but specular ore has been found only in loose or float pieces.[49]

Conclusion.

This sketch of the iron ores of the Province is of necessity fragmentary and incomplete. No individual man has been able to explore the whole field. The officers of the Geological Survey have been working upon it for half a century, yet there are thousands of square miles in the mineral-bearing regions of the Province which remain virgin ground for them. Prospectors have traversed many districts in a hurried way, but there are large areas which their wandering feet have not trodden. Nothing has been attempted here but to bring together, in condensed form convenient for reference, the information which scientific explorers and mining prospectors have gathered, and which has been recorded in reports, documents and papers of different kinds during the last half century. Doubtless many other bodies of ore will be discovered, especially when mining operations begin to be carried on; and some time in the not far off future the Bureau may be able to present a fuller, more accurate and better rounded report on those latent resources of our Province than is possible at present. But the information now given may be the means of aiding and stimulating further search, and may possibly also be the means of directing the attention of capitalists and iron masters to a realm of opportunity second to no other remaining open to enterprise upon the American continent.

ONTARIO'S IRON ORES AT THE WORLD'S FAIR.

Catalogue of the Ontario exhibit of iron ores at the World's Fair.

As an Appendix to this paper I give the Catalogue of Iron Ore exhibits made by the Province of Ontario at the World's Columbian Exposition, prepared by Mr. David Boyle, the officer in charge. It will be noticed that numerous localities are represented in this collection to which no reference has been made in the foregoing pages. The number of samples shown is 120.

1. Magnetite: Wilbur mine, lot 3, concession 13, township of Lavant, county of Lanark. Extent of deposit, 1,200 feet by 15 feet. Average lots analyze 60 per cent. iron, 6.31 per cent. silica, and .009 per cent. phosphorus, but the sample exhibited will yield about 68 per cent. iron. William and Thomas B. Caldwell, Lanark.

14. Magnetite: Lot 22, concession 9, township of Wollaston, county of Hastings. Length of deposit, one-quarter of mile; breadth, 25 feet. Thomas Nugent, Nugent P.O.

15. Magnetite: Lot 17, concession 8, township of Wollaston, county of Hastings. William Jenkins, Madoc.

16. Magnetite: Lot 15, concession 2, township of Wollaston, county of Hastings. Area of deposit, 500 feet by 180 feet. Clute & Brown, Belleville; Jenkins & Chambers, Madoc.

17. Magnetite: Lot 17, concession 8, township of Wollaston, county of Hastings. Area of deposit, 1,500 feet by 30 to 120 feet. Clute & Brown, Belleville; Jenkins & Chambers, Madoc.

18. Magnetite: Lot 18, concession 8, township of Wollaston, county of Hastings. Samples from a depth of 20 feet. Area of deposit, 1,500 feet by 40 to 60 feet. Clute & Brown, Belleville; Jenkins & Chambers, Madoc.

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[49] Report of the Commission, p. 69.

19. **Magnetite**: Lot 15, concession 1, township of Wollaston, county of Hastings. Length of bed, 1,200 feet; breadth, from 25 feet to 100 feet. Jenkins & Chambers, Madoc.

20. **Magnetite**: Township of Wollaston, county of Hastings. Jenkins & Chambers, Madoc.

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21. **Magnetite**: Lot 16, concession 2, township of Wollaston, county of Hastings. Area of deposit, 1,400 feet by 25 to 50 feet. Clute & Brown, Belleville; Jenkins & Chambers, Madoc.

22. **Magnetite**: Township of Wollaston, county of Hastings. Jenkins & Chambers, Madoc.

92. **Magnetite**: Calabogie mine, lot 16, concession 8, township of Bagot, county of Renfrew. An analysis of one lot gave 66.34 per cent. iron, 1.04 silica, .140 phosphorus, titanium a trace, and no sulphur. Calabogie Mining Company (Limited), Perth. Ontario Government collection.

93. **Magnetite**: Between the Canadian Pacific Railway and Amethyst Harbor, township of McGregor, Thunder Bay district. From a bed showing seven feet and the lower rock not yet reached. It lies in the lower portion of the Animikie rocks. Ontario Government collection.

94. **Magnetite**: Locations 1 and 2, Herrick's survey, at mouth of Little Pic river on west side, Thunder Bay district. The Canadian Pacific Railway passes through the locations. Ontario Government collection.

95-100. **Hematite**: Lots 23 to 27, concessions 11 and 12, township of Darling, county of Lanark. James Bell, Arnprior.

101. **Magnetite**: Atik-Okan range, location 402 R, Thunder Bay district. It is free from injurious combinations, and runs from 63 to over 70 per cent. of iron. The deposit forms a mountain range with the associated Huronian green schists and diorites, rising to an elevation above the surrounding plain of 50 to 125 feet, and extending along the run of the ore for nearly a mile. There are two veins of ore, with 50 feet to 60 feet of slate between, and for a good portion of the distance the veins will aggregate a thickness of 100 feet. South Shore iron experts who have examined the location pronounce it one of the best iron deposits known. H. A. Wiley, Port Arthur.

103-105. **Magnetite**: Lot 16, concession 9, township of Bagot, county of Renfrew. Ontario Government collection.

106-108. **Specular**: Lot 29, concession 14, township of Clarendon, county of Frontenac. Large deposit, fully 1,000 tons in sight; partly developed. Allison & Platt, Adolphustown.

109. **Magnetite**: Lot 17, concession 10, township of Portland, county of Frontenac. William Pursey, Verona.

110. **Magnetic iron sand**: Shore of Lake Superior, between White and Cascade rivers. Vein eight inches deep, traced for one thousand feet. F. A. Fenton, Toronto.

160. **Magnetite**: Lot 27, concession 4, township of Snowdon, county of Haliburton. T. D. Ledyard, Toronto.

161. **Magnetite**: Lot 5, concession 6, township of Lutterworth, county of Haliburton. T. D. Ledyard, Toronto.

163. **Magnetite**: Lot 25, concession 4, township of Snowdon, county of Haliburton. T. D. Ledyard, Toronto.

165. **Limonite**: Township of Snowdon, county of Haliburton. T. D. Ledyard, Toronto.

166. **Magnetite**: Lots 13 and 14, concession 10, township of Bagot, county of Renfrew.

167. **Magnetite**: Township of Clarendon, county of Frontenac. Allison & Platt, Adolphustown.

168. **Magnetite**: Paxton mine, township of Lutterworth, county of Haliburton. T. D. Ledyard, Toronto.

Catalogue of the Ontario exhibit of iron ores at the World's Fair.

169. Magnetite: Mountain mine, township or Lake, county of Hastings. R. C. Clute, Belleville.

170. Hematite (specular): Echo lake, Algoma district. P. C. Campbell, Sault. Ste. Marie.

171. Magnetite: Lot 4, concession 9, township of Palmerston, county of Frontenac. Surface shows 200 by 50 feet. Analyzes 63 per cent. iron, 2.14 per cent. silica, and only traces of phosphorus and sulphur. Ontario Government collection.

172. Magnetite: Wilbur mine, lot 4, concession 12, and lot 4, concession 13, township of Lavant, county of Lanark. Area of deposit, 1,200 feet by 15 feet. Average lots analyze 60 per cent. iron, 6.31 per cent. silica and .009 phosphorus. W. C. Caldwell, Lanark. Ontario Government collection.

174. Magnetite: Iron Duke mine, township of Darling, county of Lanark, five miles from the Kingston and Pembroke Railway. Contains by analysis 65.33 per cent. metallic iron, .017 phosphorus, and no titanium. Extent of location, 3,000 acres. Wylie & Co., Carleton Place.

175. Hematite: Echo lake, East Algoma district. P. C. Campbell, Algoma Mills.

176. Hematite (specular): Echo lake, East Algoma district. P. C. Campbell, Algoma Mills.

177. Hematite (kidney): Silver lake, Thunder Bay district. It analyzes 68 to 69 per cent. of metallic iron, with no injurious ingredients in combination; seems to be in large quantities, but owing to irregularity will require development to show the actual extent; is the same kind of ore, and is in the same geological horizon as that of the famous Colley mine of the south shore of lake Superior. It has been explored to a small extent by mining. P. McKellar, Fort William. Ontario Government collection.

178. Magnetite: Lot 25, concession 4, township of Snowdon, county of Haliburton.

179, 180, 184, 187, 191, 192. Magnetite: Belmont mine, township of Belmont, county of Peterborough.

181, 183, 185, 186. Magnetite: Lot 25, concession 4, township of Snowdon, county of Haliburton. Several outcrops of ore on lots 25, 26 and 27, extending at intervals over a space of nearly three-quarters of a mile, situated on high ground overlooking the railway track, and ore may be raised and loaded on the cars for one dollar per ton. Analysis of ore from lot 25 gave metallic iron, 62 per cent; sulphur, .025; phosphorus, a trace, and no titanium. From lot 27 gave metallic iron, 62.57; phosphorus, .025; sulphur and titanium, none. The Irondale, Bancroft and Ottawa Railway runs through lots 25 and 26, and in front of 27, connecting with the Midland branch of the Grand Trunk, about eight miles west of the mines. T. D. Ledyard, Toronto.

188. Hematite: Township of Darling, county of Lanark. Wylie & Co., Carleton Place.

189. Hematite: Township of Madoc, county of Hastings. Mrs. J. A. Wallbridge, Belleville.

190. Hematite: Iron island, Thunder Bay district. Ontario Government collection.

284. Magnetite: Lot 19, concession 1, township of Belmont, county of Peterborough. "A railway is now being constructed to the Belmont mine. It has been estimated that this ore bed contains over 1,000,000 tons of ore within 100 feet of the surface, and the stripping is very light. The ore bed has been thoroughly explored, and of the numerous samples which I have analyzed the above example is a fair average. It will be noticed that this ore equals the best of the famous Swedish Dannemora ore in regard to its low phosphorus contents, contains much less sulphur, and from 10 to 20 per cent. more iron." Wm. Molin in The Engineering and Mining Journal, November 19th, 1892, p. 484. Bessemer Iron Mining Co.

Magnetite : Lots 9 and 10 (400 acres), concession 8, township of Bathurst, nty of Lanark. Analysis shows metallic iron 65.07, insoluble silicious ter 6.66, soluble silica 44, sulphur .05, phosphoric acid .06, alumina .06, .16. John Hart, Perth.

Catalogue of the Ontario exhibit of iron ores at the World's Fair.

Magnetite : Atik-Okan location (see 101), Thunder Bay district. W. Russell, Port Arthur.

Specular : Township of Loughborough, county of Frontenac. W. G. ld collection.

Magnetite : Township of North Crosby, county of Leeds. W. G. Kidd ection.

Magnetite : Robertsville mine, township of Palmerston, county of Fronac. W. G. Kidd collection.

Magnetite : Wilson location, township of Lavant, county of Lanark. G. Kidd collection.

Magnetite : Glendower mine, township of Bedford, county of Frontenac. G. Kidd collection.

Magnetite : Lot 31, concession 4, township of Snowdon, county of liburton. Analysis by Prof. Wm. Molin, New York, shows metallic 69.246, phosphorus .012, sulphur .038, titanic acid trace only. T. D. lyard, Toronto.

Magnetite : Lot 27, concession 4, township of Snowdon, county of liburton.

442, 444. Magnetite : Belmont, county of Peterborough.'

446. Magnetite : Lot 25, concession 4, township of Snowdon, County of liburton. T. D. Ledyard, Toronto.

Magnetite : Lot 31, concession 4, township of Snowdon, county of liburton. T. D. Ledyard, Toronto.

Magnetite : Robertsville mine, township of Palmerston, county of ntenac. W. G Kidd collection.

Magnetite : Glendower mine, Janesville, county of Addington. W. G. ld collection.

Magnetite in calcite : Robertsville, township of Palmerston, county of ntenac. W. G. Kidd collection.

581. Magnetite (black Bessemer) : Easterly 90 acres of each of lots 3 d 4, concession 9, township of Palmerston, county of Frontenac. operty known as the Roberts mine, on Kingston & Pembroke Railway, out 60 miles from Kingston. Assay by J. H. Hulbert, Duluth, shows .3 of iron, with remarkable freedom from deleterious matter. When mine was worked, consignments of ore were forwarded to Pittsburgh, ., and guaranteed 65 per cent. of iron, free from sulphur. The main aft is upwards of 300 feet deep, and the ore appears to exist in immense antities. F. W. Ferguson, Winnipeg, Man.

Hematite : Wallace mine, north shore of Lake Huron, Algoma district. omas Frood, Little Current P.O., Algoma.

751. Hematite (gray) : Lot 7, concession 10, township of Portland, nty of Frontenac. Ontario Government collection.

Magnetite : Lot 7, concession 10, township of Portland, county of ontenac. Ontario Government collection.

Bog ore : Lot 28, broken front concession, township of Gainsboro' county Lincoln. Ontario Government collection.

Hematite (deep red and soft) : Lot 7, concession 10, township of Portd, county of Frontenac ; two miles from Kingston & Pembroke Railay. Drill shows a depth of 65 feet. This ore seems well adapted to e manufacture of pigments. Ontario Government collection.

Magnetite : Glendower mine, township of Bedford, county of Frontenac. nalysis gives 62 per cent. metallic iron. Good railway connection on ingston & Pembroke Railway. Ontario Government collection.

788. Magnetite and Hematite: Lot 17, concession 10, township of Portland, county of Frontenac. Ontario Government collection.

Catalogue of the Ontario exhibit of iron ores at the World's Fair.

813. Magnetite: Lot 25, concession 5, township of Darling, county of Lanark. Assay shows from 66 to 68.85 metallic iron, earthy matter 28.524, silica 2.60, phosphorus .026. Robert McGregor, Calabogie.

814. Magnetite: Lot 38, concession 1, township of Clarendon, county of Frontenac. Property has not been worked. Vein from 6 to 10 feet wide; thirteen miles from Lavant station, Kingston & Pembroke Railway. Ontario Government collection.

855. Magnetite (large sample): Atik-Okan location, Thunder Bay district. (See No. 101.) A. L. Russell, Port Arthur.

859. Hematite: Nipigon, Thunder Bay district. Wiley collection.

872. Hematite: Lot 13, concession 9, township of Marmora, county of Hastings.

897. Magnetite: Township of Glamorgan, county of Haliburton. Haliburton Mining Co., Toronto.

908. Magnetite: Coe Hill, township of Wollaston, county of Hastings, on the line of the Central Ontario Railway. The deposit is about 2,000 feet long and over 100 broad, forming a high ridge from which a large quantity of ore has been mined. The analysis gives nearly 70 per cent. of metallic iron, with a small proportion of sulphur, but no titanium. J. D. Riddell, Supt. C. O. R., Trenton.

1064-1076. Magnetite and Hematite: Cabinet specimens from various localities in eastern Ontario. J. L. Aunger collection.

1176. Magnetite: This specimen is part of a boulder found by Mr. William Jenkins of Madoc, within a few miles of that town. It is so strongly magnetic as to constitute loadstone. James F. Boyle, Toronto.

1177. Magnetite: Lot 10, concession 6 (known as "The 49 acres"), township of Madoc, county of Hastings. Mrs. J. A. Wallbridge, Belleville.

1178. Hematite: Lot 12, concession 5, township of Madoc, county of Hastings Mrs. J. A. Wallbridge, Belleville.

1333. Hematite (kidney): S. G. Fogg, Rat Portage.

1423. Hematite: Lot 2, concession 6, township of Sheffield, county of Addington. This mine is three-fourths of a mile from Tamworth, on the Napanee & Kingston Railway. Leonard Wager, Tamworth.

1455, 1472. Magnetite: Gunflint lake, Thunder Bay district. "This is said to be one of the largest and best iron deposits in Ontario. Several analyses show not less than 64 per cent. metallic iron, with freedom from deleterious matters." W. C. Caldwell, Lanark.

1485, 1486. Magnetite: Emily mine, and St. Charles mine, township of Tudor, county of Hastings. Henry Johnson, Coe Hill.

1487. Magnetite: Cameron mine, township of Chandos, county of Peterboro'. Henry Johnson, Coe Hill.

1490. Hematite: Arthur mine, township of Chandos, county of Peterboro' Henry Johnson, Coe Hill.

1492. Hematite: Township of Wollaston, county of Hastings. Henry Johnson, Coe Hill.

1561. Limonite: Echo Bay. Nelson Simmons, Echo Bay.

IV.

TREATING IRON ORES AND METALLIC IRON.

Enquiry into production and consumption.

It has been shown that we have iron ores in many localities, east, west and north. We have bog ores, red and brown hematite ores, magnetic ores and carbonate ores. But we have not one working mine in the Province, nor one blast furnace for the smelting of iron ores. The United States is making and using about 9,000,000 gross tons a year, being at the rate of one-seventh of a ton or 320 lb. per head of the country's population. What the consumption is in Canada cannot be so definitely ascertained. A small portion of the whole is produced in the country, the quantity of which is known. The great bulk is imported, chiefly from Great Britain and the United States; part of it as pig iron, but much the larger portion as manufactured goods, or as iron and steel in various stages of manufacture. The Trade Tables of the Dominion classify the imports by articles and values, and to a certain extent by weight also. In so far as the latter classification is given we have a basis upon which to estimate the total quantity of our iron and steel imports, and for the purpose of making such an estimate the following comparative table of quantities and values has been compiled from the trade reports of the Dominion for the fiscal years 1881-2 and 1891-2:

IMPORTS OF IRON AND STEEL.

Statistics of iron and steel imports.

Articles.	1881-2		1891-2.	
	cwt.	$	cwt.	$
Band and hoop iron	73,860	129,931	92,014	143,853
Bars, rolled, etc	891,494	1,328,610	133,353	231,468
Plates and sheets	271,805	714,187	442,038	1,067,027
Carwheels and forgings	27,326	74,492	25,541	105,036
Chain cables	31,084	79,103	23,803	63,263
Slabs, blooms, etc	203,888	222,056	64,397	56,186
Bridge and structural iron	49,664	212,527	6,018	27,363
Nails and spikes	11,382	51,217	9,871	40,276
Scrap iron and steel	26,545	20,406	740,687	507,018
Pig iron	1,268,620	1,023,012	1,378,360	886,485
Railway iron (rails, fish plates, etc.)	117,667	184,459	126,329	189,199
Rolled beams, etc	41,921	83,852	153,510	220,287
Nail and spike rods	16,661	24,806	16,795	36,090
Wire	121,328	455,464	72,149	219,643
Locomotive tires	8,943	45,180	27,609	86,294
Iron and steel for ships	8,978	45,819	36,703	70,663
Steel ingots, bars, etc	328,382	895,857	159,994	421,530
Steel rails	2,279,959	3,531,330	1,654,935	1,738,661
Steel for manufacturers	1,002	5,074	45,683	180,901
Totals	5,780,509	9,127,382	5,209,780	6,291,243

Averages of value.

The average value per net ton in the first of those years would therefore be $31 58, and in the second $24 15 In 1881-2 the total value of our imports of iron and steel was $17,075,588, and in 1891-2 it was $12,641,442.[1]

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[1] In 1881-2 the value of dutiable iron and steel was $12,301,974, upon which the duty levied was $2,593,994.04, or 21 per cent. The value of the free was $4,773,614. In 1891-2 the value of the dutiable was $9,968,409, upon which the duty levied was $2,792,[illegible]8.12, or 28 per cent. The value of the free was $2,673,033. The decrease in values of the Canadian imports

Pig iron equivalent of consumption.

Consumption per capita.

Assuming the average values per ton to be the same as those deduced from the table, the total quantity imported in 1881-2 would be 540,709 net tons, and in 1891-2 it would be 523,455 tons. Of these quantities pig iron constituted only 63,431 tons in 1881-2, and only 68,918 tons in 1891-2, the balance in the respective years being manufactured or partly manufactured iron and steel. In order therefore to make a fair comparative estimate of consumption per head of population, allowance should be made for waste in the refining of pig iron when remelted for making cast or rolled iron and for conversion into steel. Sir Lowthian Bell estimates the waste in the conversion of pig iron into steel by the basic process at 25 to 30 per cent., and by the ordinary Bessemer process at 12 per cent.[2] But of course the rate of waste will vary with the qualities of iron treated, and also no doubt with the processes used. If we take an average waste of 10 per cent., which I think is very moderate, the iron and steel imported into Canada in the manufactured and partly manufactured state will represent an equivalent in pig iron for 1881-2 of 530,310 tons, and in 1891-2 of 505,040 tons. In the first of these years the quantity of pig iron made in Canada was about 25,000 tons, and in the second it was 30,294 tons. Add the quantity which was imported as pig iron in the respective years, and the total consumption of the country would be the equivalent of 618,741 net tons of pig iron in 1881-2 and 604,252 tons in 1891-2, or at the rate of 288 lb. per head of population in the former and 252 lb. in the latter year. If the waste by conversion was taken as 15 per cent. the average consumption per head in the first named year would be 302 lb and the second 264 lb[3] But this rate of consumption is not uniform over the whole of Canada. In the more prosperous sections it will be highest, unless there should be exceptional circumstances, like

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of iron and steel is a consequence of the fall which has taken place in prices in the countries of production. An average of quotations of pig iron given in the London Iron for six months ending December 31 of 1881 and 1891 shows that the price of Scotch warrants (Glasgow) in the former period was 49s. 8½d. and of Cleveland warrants (Middlesboro') 40s. 8d., and in the latter period 47s. 3d. and 40s. 0½d. per ton respectively. Scotch pig therefore fell only 4 per cent. in the ten years and English pig only 1½ per cent. But the decline in steel was much greater, the average of quotations for steel bars (Bessemer or Siemens-Martin) at the works being for the former period £9 to £10 and for the latter £6 13s. 4d. to £7 1s. 8d. per ton, or a fall of 27⅜ per cent. This is a result due partly to increase in competition, but largely also to the more general adoption of improved processes in the manufacture of steel. Sir Henry Bessemer's process has indeed wrought a revolution in prices. When his patent was taken out in 1855 the price of steel in Great Britain was $250 per ton, and the annual production was only 50,000 tons. Thirty-two years ago, when his works were started at Sheffield, steel rails sold at $115 to $120 per ton, and in 1888 they had fallen to $20. The first Bessemer rails were made in the United States in 1867, and the selling price in Philadelphia was then $166 per ton ; five years later, when production had risen in that country to 120,000 tons, the selling price was $112 per ton. In 1874 it fell in Philadelphia to $94, in 1878 to $42.25, and in 1885 to $28.50. This great lowering of price is a result accomplished by the invention of Sir Henry Bessemer, and the outcry against the late Alexander Mackenzie for purchasing steel rails in a falling market is worth recalling in connection with it. As showing the progress made in the manufacture of steel, it may be stated that while in 1877 the total production of Bessemer steel ingots in Great Britain and the United States was 1,250,321 gross tons, it had risen in 1890 to 5,733,714 tons. But the two countries had also in the latter year produced in addition 2,139,020 tons of open-hearth steel.

[2] Principles of the Manufacture of Iron and Steel, pp. 411-12. In Carroll D. Wright's Report on the Production of Iron. Steel, Coal, etc., (sixth Report of the U. S Commissioner of Labor) the waste in making finished bar iron, computed from records of twenty establishments, is found to be 18¾ per cent., the average loss in making a gross ton being 482 lb. The materials used were muck bar, scrap, pig iron, and in six cases a small quantity of iron ore: but the bulk of the material was muck bar (p. 126). The waste in making steel ingots, chiefly from pig iron, computed from the records of eight establishments in the United States, seven in Great Britain and five in Europe, is 318 lb., or 12½ per cent. (p. 154). And in making steel rails from ingots, blooms and billets, the records of two establishments in the United States, three in Europe and three in Great Britain show a loss by waste of 348 lb. in the production of a gross ton, or 13½ per cent. (p. 165). At every stage in the manufacture of iron and in every heating of it there is inevitable waste of material.

[3] The higher rate of consumption in 1881-2 is due in part to the supplies of steel rails, fish plates, spikes, etc., imported that year free for original construction of the Canadian Pacific Railway. But the whole of this quantity was only 34,797 tons, or 16 lb. per head of the population, and with this allowance made the excess of consumption in 1881-2 over 1891-2 is still 20 lb. per head (or 22 lb. if loss by waste is calculated at 15 per cent.) It will be remembered however that 1881-2 was a year of boom.

y construction, to create abnormal demand in the poorer or more y settled districts. Our wants in Ontario can hardly be less than of the average United States citizen; the probability is that they are , since there are few States of the American Union as wealthy as this ce, or in which the requirements of industrial and commercial life are at. Instead therefore of a present requirement of 252 lb. per head of tion, it may be assumed that our yearly consumption is not less than .; so that the total for the Province is 300,000 gross or 336,000 net f pig iron or its equivalent, every pound of which that is not supplied by c and Nova Scotia furnaces is the product of foreign labor. The great f this iron too, as has been shown, reaches us in the manufactured only a small proportion of the whole, less than 12 per cent., is brought ig iron (a small part of which is cast scrap), and less than one per f it in the form of slabs, blooms, loops and billets. The import of ht scrap of iron and steel, upon which the rate of duty is only half of e imposed on pig iron, has increased in the ten years from 1,327 to tons, (equal to 41,150 tons of pig iron, allowing for waste in conver- so that the quantity of it now used by our rolling mills and foundries e than all the pig iron smelted in the country. Taking the pig iron e wrought scrap together, it is the equivalent of 110,068 tons of pig. a quantity sufficient if made in Canada to employ five furnaces having pacity of the Londonderry Iron Company's furnace working at its aver- the past nine years, or seven furnaces having a capacity of 50 tons per d running for 300 days in the year. But it must be admitted that a long campaign, to be carried on continuously year after year. In n, where all the pig iron is a product of charcoal furnaces, the average h shorter, as the following statistics of production for the five years 0 will show:

The bulk of iron imported in the manufactured state.

Imports of pig and scrap iron.

The example of Sweden.

——	1886.	1887.	1888.	1889.	1890.
urnaces in blast	161	164	162	150	154
ig iron made, metric tons	442,457	456,625	457,052	420,665	456,102
otal time for all furnaces in blast, days	39,777	40,582	39,840	35,859	37,892
verage daily product per furnace, tons	11.12	11.23	11.47	11.73	12.04
verage time per furnace in blast, days	242.5	247.5	246	239	246

erage campaign of charcoal furnaces in Sweden therefore is only 244 anging in the five years from 242½ to 247½ days a year; and it would 39 furnaces of the same capacity, running for the same average time, t the pig iron with its equivalent of scrap which is now used in this Pro- But the capacity of furnaces aside, there surely is here an opening for aking in Ontario if all the conditions exist which favor production on ageous terms. Iron manufactures of various kinds have been carried many years in almost all our towns and cities; but the raw material ne from outside sources, with its cost enhanced to manufacturers and ers by duties, freights and commissions. If it were made at home as and of as good quality as it can be supplied by the iron masters of ited States and Great Britain it would unquestionably be a great boon, g in the opening up of our iron mines, the utilization of our timber for l fuel, the employment of labor, and, it is to be hoped, in the profit- vestment of capital. And as the industry became established and hened, cost of production would be lowered, iron manufactures would e in variety and volume, and by degrees Ontario and the whole of might become, as regards the iron industry, a self-contained country.

Advantages of producing the raw material at home.

QUANTITY AND QUALITY OF ORES.

No prudent man is likely to take an interest in iron mining or iron making without first satisfying himself that ores can be procured at points convenient for shipment in sufficient quantities and of suitable qualities for the supply of a furnace.

Evidence of supplies of or s in

In so far as quantities are concerned, it is believed that we have an abundance in Ontario. Indeed the evidence of scientific and practical men, who may be presumed to speak with authority, is that we have an overflowing abundance of ores of different kinds, but the magnetic ore chiefly, owing to the occurrence of this variety in the Archæan rocks. Yet it is never absolutely safe to depend upon surface indications of quantity, and the cautious man would require such further proofs as actual workings or diamond drill explorations can alone in many cases afford. Where a range of ore rises to a great height above the general level of the country and may be traced by exposures for long distances, as in the case of the Atik-Okan and Mattawan, or where level beds are observed extending over large areas, as in the case of the Mesabi, in the northwestern part of the Province, the question of supply can hardly be raised. In the eastern part of the Province however the shows of iron ore occur on a less gigantic scale, and although some of them are proven to be large bodies there are others in which the quantity is very doubtful. There are known cases indeed which in what appeared to be a large deposit turned out to be a mere surface show, to the serious disappointment and loss of parties who had purchased the property. Mining engineers of reputation employed in directing the opening up of veins of gold, silver, nickel, copper and other ores will seldom counsel the building of expensive reduction works until enough ore has been mined to pay for working expenses and cost of the works; and this is safe counsel to follow also in dealing with iron mines and blast furnaces.

northwestern and eastern Ontario.

An unfortunate experience as regards quality.

As regards quality, it has to be confessed that our ores do not enjoy a high reputation with furnace men, especially in the United States. It is true that they have not been tested in large quantity, nor from many mines; but most of the shipments made were unfortunate, being chiefly hard magnetites and high in titanium like the ore of the Chaffey mine, or high in sulphur like the ores of the Glendower and Coe Hill mines. The unsuccessful attempts at iron making in the Province too have added their weight to the suspicion. And so, to use a phrase familiar to iron men, Ontario ores have received a "black eye." In the United States the magnetic ores are also largely impure, being found in some localities high in titanium, in others high in phosphorus, and in others high in sulphur; and as a result of discoveries of very large bodies of clean hematite or specular ores in Michigan, Wisconsin and Minnesota, smaller relative quantities of magnetic ore are used in blast furnaces in that country now than formerly. In 1880 the total output of the iron mines of the United States was 7,120,362 gross tons, of which 2,243,993 tons was red hematite and 3,134,276 tons was magnetite. In 1889 the total production had risen to 14,518,041 tons, whereof 9,056,288 tons was red hematite and only 2,506,415 tons was magnetite, or 62.38 per cent. of the former and 17.26 of the latter. Of other ores, 17.38 per cent. of the whole was brown hematite and 2.98 per cent. carbonate ore. During the decade red hematite had risen from 31.52 to 62.38 per cent., and magnetic ore had fallen from 29.97 to 17.26.[4]

Impure magnetic ores of the United States.

Relative consumption of ores in the States.

MECHANICAL TREATMENT OF ORES.

Enriching and cleaning ores at the mines.

In a number of instances, Mr. Birkinbine says in the last census report, the ores are treated at the mines to enrich them. Most of the carbonate ores are roasted to drive off the carbonic acid and the sulphurous ores to drive

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[4] Report on Mineral Industries in the United States at the Eleventh Census, 1890, p. 7.

Magnetic concentration of ores.

Classes of magnetic separators in use.

A large field for separators.

Average percentage of metallic iron in United States ores.

off the sulphur, while some of the brown hematites are roasted to facilitate the crushing of lumps or to drive off an excess of water. Washing appliances are used at most of the brown hematite mines to remove clay, sand, etc., from the ores before they are shipped to the furnaces, while jigs are employed to a limited extent for cleaning red hematites and magnetites. "The year 1889," Mr. Birkinbine says, "marked a revival in magnetic concentration, whereby ores carrying smaller percentages of iron than would pay for their exploitation and shipment, or iron ores which have an excess of phosphorus as apatite, or of sulphur in the shape of pyrites, are granulated and passed over various forms of apparatuses in which are currents of electricity or fixed magnets to attract the magnetic material, allowing the non-magnetic to pass away as tailings. This revival in 1889 was confined largely to the construction and equipment of plants for treating ores on a liberal scale, or experiments with various machines under different conditions. As a result of this the amount of such ore produced was small, but subsequently the completion of plants, aggregating a cost of over $500,000, their operation and the results of experiments, made this feature an important one, and one which will probably grow with each year."[5] The amount of iron ore passed through water jigs or magnetic separators in 1889 was 95,425 gross tons, and in 1891 the quantity increased to 98,546 tons of magnetically separated ore and 110,777 tons of jigged ore. In this last year there were 62 magnetic separators in operation in the United States, including machines of the three following classes: (1) Those in which the trajectory of falling material is altered by introducing the attraction of a magnet, to draw the magnetic portion away from the non-magnetic. (2) Those wherein the ore is fed to a revolving drum or drums in which is a magnet core, the shells of the drum being either of alternate magnetic and non magnetic strips or entirely of magnetic or non-magnetic material. (3) Belt machines, in which the ore is fed to a belt or series of belts passing under or over magnets or magnetic drums, the machines working sometimes in water and sometimes dry. "There is apparently a wide field for magnetic separation," Mr. Birkinbine says, "especially in the States of New York, New Jersey, Pennsylvania, Virginia, North Carolina and Michigan, where there are large deposits of lean magnetic ores. At first there was considerable prejudice against the use of concentrated ore by some of the blast furnace managers, but this has been largely overcome by practice, which has proven that properly concentrated ore contributes to the good working of the furnace, and in the future this class of ore may be used largely in place of some of the higher-priced ore brought to eastern blast furnaces. This class of ore has also been used in most of the direct processes, and any development of these processes will encourage a corresponding demand for concentrates."[6] It is calculated that the average yield of metal from iron ores mined in the United States in 1880 was 51.22 per cent., and in 1889 51.27 per cent. This is not a high average, or at least it would not be so regarded where, as in Ontario, magnetic ores run up from 60 to 70 per cent. of metallic iron, and even higher; and doubtless it will have the effect of encouraging an enrichment and cleansing of ores by sorting, separating and concentration.

TREATMENT OF ORES IN GREAT BRITAIN.

Calcining the carbonate ore.

General prevalence of phosphorus.

In Great Britain even more than in the United States the impure quality of the ores makes preliminary treatment a necessity. The clay ironstone or carbonate ore which is so abundant in that country is almost all calcined to drive off the carbonic acid and water, as well as portions of sulphur which it may contain; and when so treated it yields only about 30 per cent. of metal. In the case of phosphorus it is quite exceptional, Sir Lowthian Bell observes, when any material treated in a blast furnace is absolutely free from it; the fuel, flux and ore all appear to contain it in greater or less quantities. "Beginning with the oxides of iron found in the granite formation and ending with the lake ore forming at the present day, this element is almost invariably present. It occurs almost always combined with oxygen as phosphoric acid, in the form of phosphates of iron or lime in the ore, or as phosphate of lime in the flux and fuel. When a phosphate of iron or lime is exposed to a high temperature in contact with carbon the oxygen is separated from these salts and the product is phosphide of iron or phosphide of calcium. The pig iron then dissolves the phosphide of iron, or decomposes most of the phosphide of calcium Thus it unfortunately happens that by far the largest quantity of this substance, as it occurs in the materials, is taken up by the iron."[7] In this way it happens that of the whole of the phosphorus existing in the materials not less than 90 per cent., it is calculated, finds its way into the iron.

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[5] Report on Mineral Industries in the United States at the Eleventh Census, 1890, p. 12.

[6] Mineral Resources of the United States, 1891, p. 43.

THE INJURIOUS ELEMENTS IN IRON.

Ontario ores not exceptional.

It is evident therefore that in other countries as well as in Ontario the iron ores are impure and give rise to difficulties which are not easily overcome. But the fact that they are overcome in a large measure and that new and improved processes are being tested and introduced from time to time strengthens the belief that there is nothing in the character or quality of our Ontario ores to cause them to be regarded as in any material respect inferior to ores elsewhere.

Titanium.

Phosphorus and its effects.

Of the three most injurious elements, viz: phosphorus, sulphur and titanium, the first named is not usually found to exist in injurious proportions in iron ores of the Archæan rocks, while the last named does not as a rule occur in combination with either of the other two. Phosphorus is objected to because it makes iron "cold-short," that is to say it is brittle when cold. It is the steel-maker's bane. "Phosphoric iron," Howe says, "is readily broken by jerky, shock-like or vibratory stresses, sometimes when quite trifling; it is treacherous. It sometimes affects iron but slightly, sometimes under apparently like conditions profoundly; it is capricious It unusually increases the elastic limit, thus raising the elastic ratio, an index of brittleness. It diminishes also the elongation and contraction on rupture, two other measures of ductility affecting this property like tensile strength much more under shock than under quiescent stress."[8] One of its most obvious physical effects is to induce in iron or steel a coarsely crystalline structure, and this is supposed to be the cause of brittleness in the metal.

Effect of sulphur in iron.

The effect of sulphur is to produce "red-shortness" in iron or steel, that is to say brittleness at a red heat, while for the foundry it hardens the metal. "It is thought to make malleable iron slightly tougher and softer when cold but to make cast iron harder, though this latter effect is at least in part due to its causing it to retain the carbon in the combined state. It increases the fusibility of cast iron, but makes it thick and sluggish when molten and gives rise to blow holes during its solidification."[9] Its action is generally most noticeable at a dull red heat, but when present in only small quantity the iron is readily forged at high temperatures. If however the percentage is high the iron is no longer malleable at high temperatures.

Effect of titanium.

One serious objection to titanium, upon which all authorities are agreed, is that it gives rise to a pasty and viscous slag in the blast furnace, which, besides being non-flowable when tapped, forms "bridges" in the furnace which interfere with its working. But as to its effect on the quality of iron, opinions differ. By some it is said to give hardness, toughness and strength to the metal, and that under no circumstance is the iron "cold short" or "red-short." Other authorities again, like Howe, while admitting that it often occurs in gray soft iron, affirm that the metal is so oxidizable as to make it a matter of extreme doubt if it ever exists in wrought iron or steel.[10]

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[7] Principles of the Manufacture of Iron and Steel, p. 165.

[8] The Metallurgy of Steel by Henry Marion Howe, p. 54. [9] Ib. p. 49.

Recent improvements in methods of treating ores and metallic iron.

Some of the methods of treating iron ores and metallic iron containing those hurtful elements are old and well known, while others are of recent adoption and have barely passed the experimental stage. Cobbing, roasting and washing are methods easily applied to all ores, and lime is an excellent agent in carrying off a percentage of sulphur when used as flux in the charge of a blast furnace. Magnetic separators are only useful when applied to magnetic ores which have been reduced to powder by crushing or milling. They not only enrich the ores by separating the earthy or rock matter from the oxide of iron, but also by separating such parts of phosphorus, sulphur and titanium as are not chemically united with the oxide of iron, which sometimes is a large percentage of the whole. Machines of various designs, as already shown, have been constructed for this purpose, and some of them appear to be well fitted for doing their work effectively and economically. But most of them are of recent invention, and doubtless their working will suggest important improvements both in utility and in economy.[11]

SMELTING TITANIC ORES.

Rossi's investigations and experiments.

Experiments conducted last year with titaniferous ores by Auguste J. Rossi of New York afford grounds of assurance that the titanium difficulty may further be overcome in blast furnace practice. Mr Rossi learned that ores of this class containing from 10 to 20 per cent. of titanic acid had been successfully smelted in large quantity in the Adirondack mountains, in New

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[10] On page 85 of his valuable work on the Metallurgy of Steel Mr. Howe says titanium can probably only be introduced into any malleable variety of iron by a tour de force, nor is there reason to believe that if introduced it would be beneficial. On page 369 he refers to two samples containing a small proportion of titanium, but having a high percentage of carbon. By others it is claimed that the titanium may have an excellent indirect beneficial effect on wrought iron and steel, even when little or none of it is found in them, when they are the product of pig iron smelted from titaniferous ores.

[11] An interview with Thomas Edison in McClure's Magazine for June, 1893, pp. 37-8, under the title of Unsolved Problems that Edison is Studying, gives the following interesting account of the attention which that inventor is giving to the perfecting of his methods for treating lean or impure magnetic iron ores "The most important of the campaigns I have in mind is one in which I have now been engaged for several years. I have long been satisfied that it was possible to invent an ore-concentrator which would vastly simplify the prevailing methods of extracting iron from earth and rock, and which would do it so much cheaper than those processes as to command the market. Of course I refer to magnetic iron ore. Some of the New Jersey mountains contain practically inexhaustible stores of this magnetic ore, but it has been expensive to mine. I was able to secure mining options upon nearly all these properties, and then I began the campaign of developing an ore-concentrator which would make these deposits profitably available. This iron is unlike any other iron ore. It takes four tons of the ore to produce one ton of pure iron, and yet I saw some years ago that if some method of extracting this ore could be devised, and the mines controlled, an enormously profitable business would be developed, and yet a cheaper iron ore—cheaper in its first cost—would be put upon the market. I worked very hard upon this problem, and in one sense successfully, for I have been able by my methods to extract this magnetic iron ore at a comparatively small cost, and deliver from my mills pure iron bricklets. Yet I have not been satisfied with the methods; and some months ago I decided to abandon the old methods and to undertake to do this work by an entirely new system. I had some ten important details to master before I could get a perfect machine, and I have already mastered eight of them. Only two remain to be solved; and when this work is complete I shall have I think a plant and mining privileges which will outrank the incandescent lamp as a commercial venture, certainly so far as I am myself concerned. Whatever the profits are, I shall myself control them, as I have taken no capitalists in with me in this scheme."

'Mr. Edison was asked if he was willing to be more explicit respecting this invention, but he declined to be, further than to say':

"When the machinery is done as I expect to develop it, it will be capable of handling twenty thousand tons of iron ore a day, with two shifts a day, five men in a shift. That is to say ten workmen, working twenty hours a day in the aggregate, will be able to take this ore, crush it, reduce it to cement-like proportions, extract it from the rock and earth, and make it into bricklets of pure iron, and do it so cheaply that it will command the market for magnetic iron."

When Mr. Edison speaks of "pure iron" in the last sentence, he no doubt means pure oxide of iron.

Aim of his experiments

Laboratory tests for flux.

General results.

York State, some fifty years ago, and after as full an investigation of the records of those furnaces as was available, he proceeded to make laboratory tests along the same lines. The success of the furnaces appeared to have been due largely if not wholly to the use of certain kinds of flux in the charge which give fluidity to the slag, and the problem seemed to Mr Rossi to be, to produce with titanic acid a slag fully as fusible as those admissible in blast furnace practice. In carrying out his line of experiments the aim was to operate at not too high a temperature, so that if sufficient fusible and fluid compounds could be obtained in the crucible they might then be reproduced in a blast furnace with still greater ease. Some of the experiments were made with ores, but whenever it was intended to work for a certain type of titanate no ore was used. "Titanic acid was furnished by rutile completely analysed beforehand, and the bases were supplied by adding caustic lime, magnesia, alumina and silica, chemically pure, tested each time before weighing them for such water or carbonic acid as might have been absorbed in the intervals of two experiments by some of the chemicals, such as caustic lime and silica." These bases tested in various proportions gave slags of varying qualities, careful analyses of which were made and recorded. The ores, fluxes and fuel were intimately mixed in the crucibles, having been previously reduced to powder. The results varied much according to the mixtures. In some a good liquid slag was obtained which ran out freely, while others were pasty, chilling quickly and being sluggish and lumpy in flow. Among the general results noticed were, (1) that the presence of a large quantity of magnesia and lime, without alumina, tends to diminish the fusibility, and the addition of alumina renders the slag more fusible and fluid, and (2) that the absence of magnesia, if the percentage of alumina and lime be high, with only five per cent. of silica, has a similar effect on the fusibility, the addition of magnesia increasing the fusibility and fluidity.

Testing the results in a blast furnace.

Capacity of the test furnace.

The question which then arose in the mind of the experimenter was, Could such slags be reproduced in the conditions of working of a blast furnace? Could like compounds be obtained and the iron of the ore be separated from its gangue when the materials were charged into the furnace in lumps and by distinct layers as is the common practice, instead of previously being reduced to powder and intimately mixed as was done in the laboratory? "Nothing but a direct experiment being capable of deciding this question," Mr. Rossi says, "we built a small furnace for the purpose, assuming that if, even on such limited scale with a blast hardly at 300° or 400° F. and a pressure of not over two pounds, we could obtain the calculated slags from highly titaniferous ores with no other flux than limestone (dolomitic), the materials being charged in lumps, in proper relative proportions and in layers at regular intervals, and at the same time obtain pig iron, it would be possible in industrial practice, with a better distribution of heat, a greater height of furnace insuring a complete and thorough reduction of ores, to obtain results of the same kind and even much more favorable. Slags of a more extreme composition or basicity, for instance, though found less fusible in our experiments, might become admissible, though neither advantageous nor neccessary." Accordingly a small furnace was built and tested with a view of proving upon a large scale the results obtained in the laboratory; but as this furnace was only 9 feet in height, with hearth of 12 inches and bosh of 28 inches diameter, it could not be expected to show working of a very satisfactory character. With a light charge of ore in the stack it was only natural that the iron should lose its liquidity in the small hearth; and this is just what did happen, for after rising to the tap-hole it chilled on the run. The slags however kept very fluid from the first tapping, flowing freely on the run to 10 feet from the furnace without chilling, and so continued as long as the blast was maintained. "We do not claim that everything has been settled definitely by this experiment. But it has been possible to obtain from ores

What is claimed for the furnace test.

containing some 20 per cent. of TiO_2 in a continuous manner, under the conditions of working of a furnace and on a scale certainly unfavorable to good reduction of the ores and a proper distribution of heat in the different parts, both slags and pig iron. The slags showed good fluidity and fusibility, though containing, some, $25TiO_2$ to $22SiO_2$; others $40TiO_2$ to $22SiO_2$, and some $35TiO_2$ to $14SiO_2$, with magnesia, alumina and lime as bases. No other addition of fluxes to the ores and coke was required than limestone (dolomite and calcite mixed, pure lime having been once resorted to for want of calcite); and the consumption of materials (certainly of flux, and even of coke, considering the dimensions of the furnace), was fairly economical for a 51 per cent. iron ore, viz, ore 50, coke 50, stone 21."[12]

Importance of the experiments.

Two considerations should lead us to attach great importance to the tests made by Mr. Rossi, especially in view of the success which appears to have attended them. One is, the vast bodies of titanic ores in Canada and the United States, which are at present valueless owing to the hitherto insuperable difficulties of treating them in the blast furnace. The other is, that while many of such ores are found to be rich in iron they are generally free from phosphorus, and frequently also from sulphur.

ELIMINATION OF PHOSPHORUS.

Introduction of the basic process.

The presence of phosphorus in iron threatened for a time to defeat the process of Sir Henry Bessemer for the conversion of iron into steel. Even so low a proportion as one-thousandth to two-thousandths of one per cent. suffices to make iron or steel "cold-short," and most of the British ores carry phosphorus. In 1872, seventeen years after the date of Bessemer's invention, Mr. Snelus tried the plan of lining a converter with lime, the effect of which was to reduce the phosphorus in the pig iron; but for some cause he failed to prosecute his experiments. The idea was taken up a few years later by Messrs. Thomas and Gilchrist, two young science students of London, and by using a mixture of magnesia and lime for the lining they obtained gratifying results. But where the proportion of phosphorus was high in the iron it was found that the lining alone was not sufficient to carry out the work of dephosphorization. Accordingly they added a quantity of lime to the charge, and so improved the operation as to succeed in removing 96 per cent. and over of the phosphorus initially present. This is known as the basic process, in which dolomite, a basic earth, is used for the lining, to distinguish it from the acid or common Bessemer process, in which silica is the material used for the lining. In America the basic process has not met with much favor, owing it may be supposed to two causes—one being the comparative purity of the ores, and the other the royalty charge for the use of the process.[13]

Production of Thomas steel.

The total quantity of Thomas steel produced since its manufacture was initiated is by latest accounts 19,532,000 tons, whereof 11,452,000 tons is credited to Germany. The total output of Thomas steel last year was 3,202,000 tons, of which quantity Germany and Luxemburg produced 2,013,000 tons. A valuable bye-product of this process is the slag, which consists chiefly of lime and phosphoric anhydride, both of which are valuable fertilizers.

Value of the slag as a fertilizer.

The quantity of slag made in 1889 was 600,000 tons according to Gilchrist, and it contains 17 per cent. of phosphoric anhydride and 60 per cent. of lime, which sold at 20s. to 30s. per ton at the works. For sour, peaty and clay soils it is a fertilizer of great value, but for calcareous soil it is not valuable. "It is interesting to note," Prof. Roberts-Austen says, "that the phosphoric anhydride is combined with the lime in an unusual manner. Instead of being an insoluble tri-basic phosphate, it is a readily soluble tetrabasic phosphate, and if it be finely ground the phosphorus it contains is readily assimilated by plants. At first attempts were made to treat it by various chemical methods, but it has been found best to simply grind and use it in fine powder."[14]

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[12] Mr. Rossi's paper giving an account of his experiments with titaniferous ores was read at the meeting of the American Institute of Mining Engineers held at Montreal in February of this year.

[13] The Thomas-Gilchrist patents expire next year, when a considerable development of production by their process is looked for; indeed is feared. Mr Thomas died a few years ago; but Mr. Gilchrist, who is not yet forty years of age, is said to be a millionaire in pounds sterling.

The basic process, it may be observed, is applied to the refining of pig iron, and mainly for its conversion into steel.

No method of eliminating phosphorus from the ore in the blast furnace has yet been discovered; and as to the preparatory treatment of ores containing phosphorus the magnetic separator has no doubt given the best results.

DESULPHURIZING METALLIC IRON.

The puddling process.

There are various porcesses for desulphurizing iron ores, as has been pointed out; and in the furnace a generous use of lime is highly serviceable. By puddling and by the basic process, which are essentially the same, sulphur is expelled from iron, and manganese is also a powerful agent for its removal. But after all these processes have been tried a residuum of sulphur often remains. It is not merely the sulphur in the iron ore which has to be combatted, but the sulphur in the coal or coke as well, whereby the percentage in the pig or cast iron is increased; and various devices have been tried by metallurgists to get rid of it. The importance of obtaining a suitable method has indeed become more pressing than ever before, owing to the more general use of steel which followed the introduction of the Bessemer process. During recent years a special study of the desulphurization of iron has been made, and careful experiments have been carried on by a number of well known men upon scientific lines; but while some progress has been attained there are only two processes which deserve special mention here, and both treat the iron after it has been reduced from its ore.

Growing demand for better processes.

Operation of the Hoerde process.

One of these is the invention of Joseph Massenez, a German, and is known as the Hoerde process because it was first tested on a large scale at that place. It aims at the removal of sulphur from iron by the agency of manganese—iron high in sulphur and poor in manganese being mixed with iron containing a large percentage of manganese and little sulphur. The result is that the manganese of the one charge acts upon and combines with the sulphur of the other, forming a manganese sulphide which rises and flows off in the slag.[15] The mixer is a vessel with a capacity of 120 tons, into one end of which the molten pig iron is poured as brought direct from the blast furnaces, along with a certain amount of ferro-manganese, while from the other end the desulphurized metal is poured into ladles and taken to the Bessemer converters which are used in conjunction with the process. About 1.7 per cent. of manganese is added to the charge, whereof 0.2 per cent. combines with the sulphur, the rest remaining in the iron. One effect of the mixing, it is claimed, is to give steel of more even quality when the operation is completed in the converters. The process appears to be well approved in Germany, and it has recently been adopted in two of the largest steel-making establishments in Great Britain.

Operation of the Saniter process.

The other process to which reference has been made, a later than the Hoerde, is the invention of Ernest H. Saniter, chemist of the Wigan Coal and Iron Co. of England. It is thus described by Mr. Saniter himself:

"A mixture of calcium chloride and lime is prepared, which will fuse readily at the temperature of the iron to be operated upon. The desired combination is made by grinding calcium chloride and lime together in a mill so as to thoroughly mix them, and also to bring them to a moderately fine powder. About equal parts of each are required to give the desired fusibility. This mixture is then placed on the bottom of a ladle or receiver, and consolidated by heat, or kept in position by other suitable means. The heat may be applied in the first instance by means of a blow-pipe arrangement, using blast-furnace gas, but when in continuous use the heat of the ladle itself is quite sufficient. The receiver is then filled with iron, which may be drawn direct from the blast furnace, the heat of which melts the mixture, and the latter, rising up through the metal, removes the sulphur very completely. I do not find it necessary to have reducing conditions, and indeed oxidation may be going on concurrently with the removal of the sulphur, as will be seen later on. Notwithstanding this however the sulphur is removed as sulphide. Should it be desirable to remove silicon as well as sulphur, the lime of the mixture is replaced by hydrate or carbonate of lime, or even oxide of iron in addition should the hydrate or carbonate be insufficient. About 25 lb. of chloride of calcium and an equal weight of lime per ton of iron have been found sufficient to effect purification '[16]

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[14] An Introduction to the Study of Metallurgy, p. 224.

[15] J. E. Stead in the Journal of the Iron and Steel Institute No. II. 1892, p 258.

For removing silicon as well as sulphur.

Results obtained.

In a number of experiments made with the Saniter process it was found that 73.6 per cent of the sulphur and 35.77 per cent. of the silicon contained in the iron were eliminated, and the whole cost of materials was only twelve cents per ton. The process was carefully investigated last year by Mr. Stead and the results as given by Mr. Saniter were fully confirmed by him, as set forth in a lengthy paper read before the Iron and Steel Institute at its Liverpool meeting of September last year.

Further tests of the Saniter process.

At the meeting of the Institute held in London on the 25th and 26th of May of the current year Saniter's process was again the chief subject of consideration, when papers on it were read by Messrs. Stead and Saniter. Mr. Stead's paper was occupied largely in meeting German criticisms of the process; for it is to be observed that in Germany, according to some metallurgical authorities, the process meets with difficulties in practical use which are not present in the Hoerde method.

Plant for operating the process.

Mr. Saniter's short paper reaffirmed the results previously obtained after six months' further experience of the process. The Wigan Coal and Iron Company, with whom Mr. Saniter is employed, has laid down a plant for dealing with the whole make of a blast furnace, the general arrangements of which are that the sand bed has been lowered to the ground level, whereon and in front of the blast furnace is a ladle on a carriage, the ladle being provided with tipping gear. The ladle is heated before the first operation and the mixture of calcium chloride and lime is put on the bottom, protected with a small cast iron plate to prevent the molten metal cutting under it. The metal is then run in and as soon as the reaction ceases it is tipped into the lowered sand bed and the slag is raked out of the ladle. The quantity treated at a cast is nine to twelve tons, the cost of the plant is under £250 per furnace, and the cost of materials is 4*d.* and of other cost including labor and grinding 2*d.* per ton of iron treated.

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[16] Journal of the Iron and Steel Institute, No. II. 1892, pp. 217-18. The London Engineer of May 5, 1893, writing of Saniter's method says:

"In point of cost—and the commercial aspect of an invention must always override all others—the new process compares very favorably with the Massenez process, which may be considered its principal if not its only rival. The cost of the materials used in the former case appears to be from 6*d*. to 9*d*. per ton of pig iron, or 1*s*. per ton including royalty and labor, as against from 1*s*. 6*d*. to 2*s*. 6*d*. for materials only in the latter case. The cost of calcium chloride, if applied in the converter or open hearth, is about 9*d*. per ton of steel, and this expenditure is said to effect an actual saving of about 4*s*. per ton of ingots by the reduced consumption in ore and scrap.

"The only special plant required for Saniter's process is a reverberatory furnace for drying the calcium chloride, some apparatus for pulverizing the same and mixing it with lime, and a tipping ladle. The latter is dispensed with if desulphurization is effected in the converter or the open hearth

"There is at present an almost unlimited supply of calcium chloride, it being a bye-product resulting from the manufacture of soda and bleaching powder. Its present value is about 35*s*. per ton. Not more than ten per cent. of the total quantity produced is utilised, and a new use will be very acceptable to the makers. There is of course no difficulty in obtaining plentiful supplies of limestone and lime."

Used in the basic converter also.

The process is applied not only to the treating of iron as it comes from the blast furnace, but also for its conversion into basic steel; and it is claimed by Mr. Saniter that while a basic Bessemer blow alone will get rid of about 45 per cent. of the sulphur, his dual process (first in the ladle and afterwards in the converter) will get rid of 78 per cent. The steel made by his process, Mr. Saniter claims, has been tested in Sheffield for the various purposes for which Swedish bar is used in making the highest class cutlery and tool steels with marked success. "It has also been found nearly equal to the best charcoal iron for conductivity purposes. It welds splendidly. A piece which had been welded was turned and pulled in the testing machine; it broke clear of the weld, the line of which it was impossible to detect."

Quality of the steel product.

Testimony of Mr. Snelus to the value of Saniter's process.

But perhaps the most valuable testimony to the worth of this process is one furnished by Mr. George J. Snelus, vice-president of the Iron and Steel Institute, whose authority as a scientific and practical metallurgist is cheerfully recognized throughout Europe and America. The following extract is taken from Mr. Snelus' report upon the Saniter process, which was read at the last meeting of the Institute:

His report on experiments.

"I spent two days, February 21 and 22, in personally examining the working of this process at the works of the Wigan Coal and Iron Company. Every opportunity was afforded me for investigating the process from beginning to end. All samples were taken and carefully labelled by myself, and these were analysed with extreme care in my own laboratory. I had some ingots from the Siemens cast c.1134 heated on the second day and rolled into two-inch billets. These were afterwards rolled into ⅝ round bars, and tested for tensile strain in my presence. The ingots were twelve inches square, weighing 16 cwt. They were heated (from cold) in 1 hour 20 minutes, and rolled off in twelve passes in the roughing rolls to nine passes in the finishing rolls. I was remarkably struck by the fine quality of the steel. I could not detect the slightest flaw or sign of red-shortness in any of the ingots or in the finished billets, although I examined them minutely. In fact I never saw any steel roll cleaner or better than this did, and the practical tests fully corroborate the analytical results which follow, and show clearly that this process is most effectual in desulphurizing the commonest kind of pig iron to such an extent that the highest class of steel can be made from it. The materials employed are not costly, and there is no difficulty in carrying out the process and in producing uniformly good results.

"The process is adapted either for purifying fluid pig iron direct from the blast furnace, by running the fluid metal into a ladle having a layer of the purifying materials on the bottom, and afterwards running the metal into pigs or plate metal for subsequent use in the puddling furnace, etc.; or the crude sulphury pig is treated in the basic Siemens furnace or Bessemer converter with the patented mixture, as in the casts c. 1134 and c. 1135. Calcium chloride is the purifying material in admixture with lime. This at present costs 35s. per ton packed in own drums f. o. t. St. Helens or Widnes. It is made by the United Alkali Company from residues of the Weldon process, and containing 70 per cent. absolute calcium chloride, 1 to 2 per cent. impurities, and balance water. It is dried in rough iron dishes in a reverberatory furnace before use. In purifying the metal in the ladle, fluor spar is sometimes mixed with the calcium chloride to retard the process, and some limestone is used to save lime and produce a boil in the ladle. Fluor spar can also be used with the other ingredients, lime, limestone and purple ore in the ladle, but the mixture is not quite so efficient as when calcium chloride is used."

The result.

Full details of his experiments are given by Mr Snelus, both in desulphurizing in the ladle and converting into steel, together with analyses of the metal and slag at the various stages of steel making, and also the mechanical test of the steel, and the result of his observations is summed up in these words: "That this is a thoroughly practical, reliable and inexpensive process for desulphurization, and that by it, using the basic process, white iron made entirely from cinder can be converted into excellent steel without undue waste or loss of time."

The process is by the experimental stage, and in full working order.

The process a boon to British hematite ores.

In the discussion by members of the Institute which followed the papers, Mr. Snelus stated that he had an opportunity of seeing the process at work on a practical scale and that it was not now merely an experiment. He confessed that he had gone to the place with some fear and trembling; he thought it was in an experimental stage; but when he went there he found that it was in full working order, applied constantly to a blast furnace of ordinary capacity, running in the ordinary way and the whole thing going on as a large manufacturing operation. It was simply an examination of a process going on in ordinary working—a thing carried on daily by ordinary workmen without any instructions, but of course the men must be skilled and possess a full knowledge of the process and how to adapt it. Mr. Snelus said he had often been condemned by his friends for having ruined his own district, in which is hematite ore high in sulphur, by doing all that he could for dephosphorization; but he hoped that he should atone somewhat for that by the aid which he would give to desulphurization, because it would place in the hands of hematite makers a means of producing the very highest class of steel. Therefore he thought that the process would undoubtedly be a benefit to those districts having the class of ore in which sulphur had been a trouble as well as phosphorus.

Differences of opinion.

Of course there was not entire agreement among members of the Institute on the merits of the Saniter process, and doubts were expressed by one or two members as to whether it could be depended upon for uniformity of results. Sir Lowthian Bell was characteristically cautious; that is a constitutional quality with him, and he is to be respected for it. But Sir Lowthian discussed the subject mostly from the point of view o a theorist, for he had not had an opportunity of examining the process in practice; and it is to be stated that the German objectors have also in the main spoken and written from the same point of view. Such testimony cannot therefore have the same weight or value as the testimony of men like Mr. Snelus and Mr. Stead, who have made careful study of the process after witnessing its operation.[17] Practical demonstration, in which there is not a possibility of deception, will be accepted in preference to the most ingenious speculation or theory.

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[17] See Report of the Proceedings of the Iron and Steel Institute in Iron, May 26, 1893. At a meeting of the Cleveland Institution of Engineers held December 19, 1892, Mr. Saniter read a paper descriptive of his process in which he said:

"The application of the process to the manufacture of basic pig iron presents in the first instance the possibility of dispensing with the use of expensive manganiferous ores, and the further possibility of removing the difficulty hitherto experienced in using direct metal for steel making, owing in the one case to high silicon and conversely when the silicon is low to high sulphur. This may be simply done by using the dry mixture for the removal of sulphur only, and should the silicon be high by adding a bucket of water to the mixture a short time before tapping the furnace." Commenting on this feature of Mr. Saniter's paper at the meeting, Mr. Stead said there seemed to be at the present time a rage for studying how to get rid of sulphur. It is not so long ago, he said, that a beautiful process was perfected in Germany, but it required a large amount of manganese, which is expensive. At Wigan he had witnessed successful experiments on Mr. Saniter's process with iron containing only 0.4 per cent. of manganese, and though the sulphur was 0.4 per cent. it went out almost magically a few minutes after the chloride of calcium was added. They did not understand exactly what action took place, but the fact remained that the sulphur was eliminated, and in the course of time they would no doubt understand the action itself.

LESSONS FOR ONTARIO.

Progress of improvement in methods of treating ores and metallic iron.

The long story of invention is not closed, and in so far as the art of iron making is concerned it is not likely to close while impurities in ores and fuels continue to baffle the ingenuity of man. But the iron masters are in the line of improvement, and aided by science they are making sure headway in the face of many difficulties. The iron ores of Ontario are no worse than ores elsewhere; indeed it is almost certain that they are freer from at least one objectionable element, phosphorus, than those of other countries in which supplies are mostly found in the more recent rock formations. Better ways of treating ores in preparation for the blast furnace, and better ways of improving and refining iron and converting it into steel, as well as of strengthening it in combination with other metals, are being found out by skilled men in the laboratory, the furnace and the workshop; and every advance so made is a gain in which the whole world may share. There is not a process in the preparation and smelting of ores, not an improvement in the blast furnace, not a method of refining or working the metal, not an economy in any operation from opening the mine to the last touch of finish in the workshop, but is as free and open to us in Ontario as it is to the people of any country or state in Europe or America. Why then should not effort be directed to utilize one of the most valuable of all the raw resources of our country, converting it into wealth by the wisely-controlled agencies of capital and labor, and making it an instrument for the production of greater wealth by ways and means almost without limit and number? A talent kept buried in the earth will be no more than a talent a hundred years hence, while if rightly utilized it may reproduce itself a thousand fold in a hundred years.

The buried talent.

V.

FACTS AND OPINIONS ON THE IRON INDUSTRY.

The narrative of the failures and successes of iron making in our country, of the means which have been adopted by Governments to aid and encourage the industry, of the iron ore resources of our Province and of improved methods for treating ores in the process of extracting the metallic iron, may now be appropriately followed with information and opinions gathered in a wider field, but having direct reference to the possibilities of establishing works for the production and manufacture of iron in Ontario.

VARIOUS ASPECTS OF THE INDUSTRY PRESENTED.

In the statements which follow, Dr. A. P. Coleman, Professor of Metallurgy and Assaying at the School of Practical Science, treats of the development of our mineral resources in a general way; Samuel D. Mills gives the benefit of his experience with charcoal furnaces in Michigan and Texas; Mr. Ritchie outlines a scheme for utilizing iron ores along the line of the Central Ontario Railway in connection with nickel ores of the Sudbury district; and Messrs. Pusey, Ledyard and Conmee express opinions on a variety of practical features relating to the industry.

PROFESSOR COLEMAN'S STATEMENT.

Coleman.

"From a geological point of view the Province consists of a comparatively small southern portion formed of paleozoic rocks with no important deposits of minerals, but covered by as productive soil as any in America, and of an immense northern and northwestern area of Laurentian and Huronian rock, of little use for agriculture, but rich in mineral resources. The fertile southern portion was naturally settled first by a thrifty, prosperous agricultural population, little inclined to unusual speculations of any kind and specially ignorant of mines and minerals. Losses in the Madoc gold mining excitement confirmed them in the belief that mines, especially in Ontario, were very dangerous investments.

Agricultural and mineral wealth of the country.

"As an agricultural country Ontario has practically reached its limit. If the Province is to advance in the future as in the past, or if it is not to retrograde even, the great northwest must be turned to advantage. Its stores of timber have hitherto been a source of revenue, but fires and the work of the lumberman are steadily diminishing them. The only hope for rapid advance in the future lies in the development of the mineral resources, especially of the Huronian tracts, which as far as explored have proved rich in ores. Iron ores of unsurpassed quality and in large amounts are found in the Province; copper ores occur in very large quantities; and the world's largest known source of nickel belongs to the Province, not to mention ores of silver and gold; so that Ontario may justly be described as one of the richest countries in the world in mineral resources.

"Notwithstanding this, Ontario has been disappointingly slow in developing its mines, and what has been done has been the work not of Ontario men, but of Americans or Europeans, and has frequently been carried on in ways unsuited to our conditions. Every new mining region has its special conditions and difficulties, and the best methods of meeting them can be determined often only by costly experiments on a commercial scale. No mining region can reach the highest prosperity merely by shipping its ores to other countries, Coleman.

Advantages of smelting works.

and it is safe to say that until Ontario ceases to sell its ores and low grade mattes and begins to smelt and refine its own iron, steel, nickel and copper, no great advance is likely to be made. The establishment of smelting works of any kind on the right scale and wisely managed will give a market for many ores of too low grade for export, and will serve as a nucleus for a dozen other industries of great importance.

"The starting of the manufacture of good quality steel, for instance, would probably be followed by the refining of at least part of our own nickel, to be used in making nickel steel, and that by the refining of the associated copper. I need not say that this would imply a demand for skilled and highly paid labor, would lead to the building up of great manufacturing centers through the cheapness of the main raw materials, and would afford the best possible markets for our farmers.

Skilled labor and good markets.

Capital and experience required,

"But the founding of such metallurgical establishments on the proper scale demands a large capital and great experience; and at the outset there would probably be little or no returns until the experimental stage was over. In many other countries this costly and discouraging initiatory period has been tided over by governmental aid until things had reached a self-supporting basis.

"In a purely agricultural country like Ontario encouragement is particularly needed, since our people have not yet developed the skill and experience required for success in this direction; and the foreigners who might be expected to undertake the work are already interested in the success of rival establishments in the United States, England or other countries.

which ought to be encouraged by Government aid.

"Under all the circumstances it appears that our Government would be justified in aiding in whatever way seems wisest the establishment of smelting works in the Province, such aid of course to cease when no longer needed. Such a course has been adopted with advantage by many other countries. Norway and Saxony have even owned and worked important mines and smelting establishments with great benefit to the State.

A turning point in our history.

"In my opinion Ontario has reached an important turning point in its history. If no new departure is made our Province must stand still or even retrograde, while a wise utilization of our mineral resources will give the starting point for a growth of population and wealth which will keep Ontario in the front rank as compared with the rest of the world.

Financial aspect of the question.

"To the Government of Ontario this question has a very direct importance from the financial side. The revenues now derived from the sale of timber limits will not last always; but if mining and smelting receive the proper attention this loss of revenue may be much more than made up in royalties."

SAMUEL D. MILLS' STATEMENT.

Mills.

"I am an old countryman by birth. I studied at the Royal School of Science, Dublin, intending to follow mining engineering, but family circumstances led to my abandoning that idea, and for seven years I did nothing at it. I formerly resided in Kingston, Ontario, for nearly four years. I have had no experience in iron-making in Canada. During the time I lived in Nova Scotia, about three years, I was a partner in a private company engaged in mining barytes, but owing to some changes in the market we could not work at a profit, and, there being indications of lead, copper and silver on the property, I was engaged in attempting to develop these. I lived in Nova Scotia from 1874 to 1877, and took advantage of opportunities I possessed of visiting and studying the working of the furnaces at Londonderry. Mr. Brown, the general superintendent, being a friend of mine, proposed that I should take the position of chemist and assistant superintendent, but a change in the management prevented my doing so. When I went to Kingston I opened a mineralogical and mining office, and remained there for three years trying to work up some interest in connection with the mines there. I examined many of the mines in that district at that time. I examined the iron mines north of Kingston, in Frontenac principally, and also in Lanark and other parts of that country. I was partly exploring for my own purposes and partly examining for others. Folger Bros. got me to go up and make a report on the Mississippi iron property, and I examined some mines farther north for my own satisfaction; these mines were being worked then. I wrote a report for Messrs. Folger which was published in the Kingston Whig at the time, somewhere about 1879 or 1880.

Mills.

Blast furnace experience in Michigan.

"In 1881, finding that business continued dull, and it was impossible to get up any interest in mining at Kingston, I abandoned the attempt. I got an offer to go to Michigan to take charge of the new chemical works and blast furnace at Newberry, in the northern peninsula, about 75 miles from the straits of Mackinaw. I remained there for nine months, when I went to St. Ignace and took charge of the Martel furnace and chemical works, where I remained for about eight years. The St. Ignace furnace was built before I went there, and had been running about eighteen months. The supply of ore for this furnace came from many different mines in Michigan, mostly from the neighborhood of Ishpeming. Some of it came by rail a distance of about 165 miles. We used a mixture of ores. During the last fifteen months I was there we experimented with thirteen different kinds of ore, showing the range of ore obtainable there. We used brown hematite, a certain proportion of red hematite, hard specular and magnetic ore. When I speak of red hematite I mean both the soft, earthy variety and the hard specular ore. The regular practice in that furnace was to use a mixture of five different kinds of ore in the same charge, mixed in given proportions. In the manufacture of car-wheel iron the obtaining of a proper quality of chill is a matter of very great nicety, and one requiring very close attention, and the mixture of the ores was made with the view of accomplishing that object. We experimented carefully so as to find out the proper mixture, and the proportion of the various ores was regulated accordingly. We never tried to produce a suitable quality of iron from magnetic ore alone, as we had no occasion to do so. It would not have been economical, because the magnetic ores were the highest priced ores we used. We used only a small proportion of them, what we could not do without. The bulk of the ores were hematite, chiefly red.

The St. Ignace furnace.

Quality and cost of ore smelted.

"During a run of 167 days from April to October, we experimented on the following varieties of ore:—Imperial, a brown hematite; Webster, the same; Cleveland Lake, a soft red hematite; Old Mine, a similar quality of ore; Cleveland Scotch, Dexter, East New York No. 2, and Lake Superior No. 1, all hard red hematites; Michigamme and Comrade, magnetic ores. The names given are those of the mines. Some of the hard red hematite ore was specular. The following are the quantities we used during that campaign:—Imperial, 3,405 tons; Webster, 115 tons; Cleveland Lake, 3,722 tons; Old Mine, 2,369 tons; Cleveland Scotch, 3,668 tons; East New York No. 2, 622 tons; Lake Superior No. 1, 954 tons; Michigamme, 1,016 tons; Comrade, 91 tons, and Chelsea, 99 tons. The average yield of iron for the 167 days was 57.8 per cent. The mixtures did not remain the same for the whole time; for a week or so perhaps we ran upon one mixture and then changed over and tried another. Of some of the ores, as you will notice, only very small quantities were used. I cannot give the percentage of iron in all of these ores; but here are averages of a few of them:—Imperial, 57.8 per cent of iron; Lake Superior No. 1, 65.2 per cent.; Cleveland Lake, 61 5 per cent.; Cleveland Scotch, 62.6 per cent.; Michigamme, 65.5 per cent. The total make of iron during the run was 9,361 tons. I have not got the exact figures as to the cost per ton of the iron ore laid down at the furnace, but the quantity of ore required to make a ton of iron cost us $6.55, the ore yielding an average of 57.8 per cent. of iron. When I speak of the ton of ore I mean the net or short ton of 2,000 lb., in which way be bought all our ore, but the iron was sold by the long ton of 2,260 lb. I give the product in long tons, but the ore in short tons. In Texas we allow 2,268 lb. to the long ton.

Mills.

"We manufactured our own supply of charcoal to a large extent. We made it at two different sets of kilns, and also bought some from outside parties. One set of kilns was twelve miles from the furnace, and the other was between twenty-four and twenty-five miles up the railway. We used beech, maple, birch and a little elm in making charcoal, as little elm as possible. It was all hardwood except a little soft maple. The timber was good and heavy. We could cut from 40 to 45 cords of wood from an acre. We cut up the whole tree, everything down to three inches thick. A cord of wood would make about 45 bushels of charcoal in the kilns. We did not make it in any other way; we did not use any pit coal. I cannot tell you what the charcoal weighed per bushel; we called 20 lb. a bushel and settled for it and paid our colliers, etc., on this basis. At one time we kept accurate account of the coaling and handling of 2,000 cords of wood, and the resulting charcoal cost us 4¼ cents per bushel f. o. b. cars at the kilns. The freight to the furnace was three-quarters of a cent per bushel. During the campaign I mentioned we used 870,000 bushels of charcoal. The cost of the coal per ton of pig iron was $6.89. At the second set of kilns, which was not so well managed, the coal cost us more, and the coal we bought from outside parties cost us very much more than it ought to have done.

Production of charcoal fuel.

Flux.

"With regard to flux, we were most fortunately situated. During the last run I decided to extend the stock-house, which was not large enough to carry a proper supply of ore for the winter. On commencing our excavations I found that the upper end of the stock-house was built on limestone, and we excavated the limestone for flux and extended the stock-house at the same time. Before this we had quarried the stone about a quarter of a mile from the furnace. The quantity of limestone we used for flux varied according to the nature of the ore. We used a very small proportion, as our ores were low in silica and were to some extent self fluxing. The Webster, Imperial and some of the other ores carried a good deal of lime, so that our proportion of limestone ranged from 40 to 70 lb. per charge, averaging perhaps 60 lb. An average charge consisted of 1,800 lb. of ore; with that we would use 50 or 60 lb. of limestone, which is a very low proportion. We did not put an estimate on the cost of the limestone, as under the circumstances it really cost us nothing; we were obliged to excavate it in order to extend our stock-house.

Cost of labor.

"As to the furnace itself, a correct description of it, giving the dimensions, etc., was published in the Charcoal Iron-Workers' Journal. The machinery, blowers, etc., were also described in that article. We had 26 men employed about the furnace; then there were the engineers and others; in all there must have been 38 men. The cost of labor per ton of iron was $1.42, which includes superintendence, fuel for switch locomotive and blacksmith's wages.

Total cost of production.

"The facts which I have given regarding the campaign referred to will apply to the general run of our work. We have done better, and we have done worse. At the prices which we were paying for the ore, labor, etc., the total cost of production of iron per ton was $15.70. According to the books in the office the cost was $15.94; but there were some charges which ought not properly to have been entered against it. The pig iron was used exclusively in the manufacture of car wheels, and very largely by our own people. The furnace was built for the express purpose of supplying the Erie Car Works, the property of Davenport, Fairbairn & Co., at Erie, Pennsylvania.

Experience in Texas.

"I was nine years in Michigan altogether, leaving there early last year and going to Texas. I did not build the furnace at Texas; it had run for about six weeks and then shut down before I took charge. It is supposed to have a capacity of 50 tons, and I hope we shall make it a 50-ton furnace, but owing to defects in construction it did not run over 40 to 45 tons. It is larger than the Martel furnace; it is 60 feet high by 11 feet bosh, and 6 feet

6 inches crucible. There are six tuyeres; the Martel furnace had five. We use the warm blast in Texas, from 500° to 900°. At the Martel furnace we used from 1,100° up as high as 1,800°; I have run as high as 1,800°. We use the gas from the furnace in heating our boilers and heating stoves. The furnace is located at New Birmingham, Cherokee county, Texas. Mills.

"The ore used at the furnace occurs in what is known as a blanket deposit. It is found on the tops of hills, at an elevation of about 700 feet above the Gulf of Mexico, throughout the counties of Angelina, Rusk, Cherokee, Smith, Henderson, Anderson and several others. The level is so invariable that you can almost tell the elevation at which you are above the gulf by finding this ore. It is a brown hematite, somewhat similar to the bog ores of Quebec. It is a bog ore formation and is found near the surface, the earth being removed by means of ploughs and scrapers. The ore is then broken up with bars and picks, very little powder being used, and after stripping a bank of ore the earth from the next strip is thrown into the excavated place, so minimizing the cost of excavation. The beds range in thickness from 18 inches to 3 feet 6 inches. It is covered with sand, and generally underlaid by sand also; it is not found in vegetable mould. The thickness of the overlying sand varies from nothing to 12 feet, but we do not touch the deeper portions. If the bed is covered with more than six feet of sand we leave it. The ore analyzes 45 per cent. iron, and will yield in the furnace somewhere about the same. There has been an amount of irregularity in the output of the furnace that shows an irregularity in the ore itself. It has appeared to run from 45 to nearly 50 per cent. in the furnace. It must be more than that in the ore, but pig iron is not all iron by a good deal. The softer grades particularly run down as low as 96½ per cent. of iron, the balance being silica and carbon. There is a large amount of graphitic carbon, as much as two or three per cent., in the softer irons. There is some sulphur and phosphorus in the ore. I have not the analysis here with me, but it sometimes runs as high as 0.2 per cent. of phosphorus. There is a little sulphur; some analyses I made myself ran from a trace to .06; it varied considerably. We lay down the ore in the stock-house at a cost of 65 cents a ton. Our labor is not so very cheap; it costs us from $1.25 to $1.50 per day. It is negro labor chiefly, and we find it efficient. With a gang of forty or fifty negroes we have two to four white men as drillers; and in case we use a little powder we employ the white men to drill. We pay our foreman miner $2.50 per day. Bog ore.

"Our company makes its own charcoal. Up to the present time we have been making it in pits exclusively; but the intention of the company is to raise some more capital and go into larger development, probably building another furnace, and more kilns for making the charcoal. There are two kilns already built, which I put up last year. The supply of wood for charcoal varies in distance from the furnace. Our kilns will be located at the furnace, but that will have nothing to do with the point of supply of the wood, which will be brought to the kilns by rail. Our charcoal has been costing us somewhere about seven cents per bushel; we expect to cut the price down considerably. Charcoal.

"We ran our last campaign about eight months, and then decided to shut down for alterations and repairs. There were a great many repairs found necessary, and a great many alterations were required in the stock house and in other ways. We are subject to very heavy rains there, and the upper works of the furnace were leaking so that the rain got into the furnace. The low price of iron had a good deal to do with our shutting down; it was the principal reason. Iron went down to such a price that it would only net us $12 per ton, and it was costing us $11.75 to $11.90 to produce it.

Iron ores of the Kingston district.

"Coming back to Ontario, I cannot say that I have any other knowledge of the iron deposits of this Province than I gained during my explorations in the neighborhood of Kingston. From what I then learned I formed the opinion that there were large bodies of iron ore in the Frontenac country and its vicinity. I felt certain that there was a large amount of iron there. It was of good quality, not to be surpassed anywhere. It was chiefly magnetic. There were some indications of hematite, but hematite ores are not to be discovered by the use of the dip needles; nothing but actual work will show their presence unless they crop out. The only way to find them is by using the diamond drill. I have seen indications of outcroppings. Where discoveries are made in Michigan and Wisconsin of hematite ores the diamond drill is used very largely in prospecting for them. There will always be more or less indication on the surface in the case of hematite ores from the discoloration, but I have heard of borings being made without any surface indication. Brown hematite is always found by the discoloration. It is almost always at the surface, and you will find a very frequent indication to be the deposits from the water. If you find a spring of water leaving a deposit of brown ore you may be perfectly certain that there is a body of it somewhere in the neighborhood. I certainly recommend the use of the diamond drill in prospecting for red ores, and for magnetic ores as well. In the case of magnetic ores we do a good deal with the dip needle, but as a confirmatory test I consider the diamond drill is necessary.

Prospecting with the diamond drill.

Treatment of magnetic ores.

"In furnace work it is found to be very desirable to use a mixture of hard and soft ores; but hard magnetic ores may be greatly improved for furnace treatment by roasting. By adopting the following plan such ores can be used for smelting without mixture: take a portion of magnetic ore and use it in its raw condition, and roast the rest of it. In New Jersey this plan is followed. The object of the roasting is to change the nature of the ore and convert it from the protoxide to the sesquioxide, thus virtually changing it into a hematite ore. The advantage of the hematite is that it is an open ore, more open than the magnetic, the consequence being that in the furnace it takes up carbon more readily and parts with its oxygen more rapidly. The reaction is much more rapid with hematite ore than with magnetic; the reason being that in the first place the latter ore is dense throughout, and in the second it has a smooth polished surface, consequently it resists the action until it goes down a certain distance in the furnace. Long before the hematite ore has reached that level in the furnace it is to a great extent reduced and thoroughly saturated with carbon. The practice of roasting magnetic ore and using ore thus treated with raw magnetic ore in the furnace is followed at Boonton in New Jersey; when I was there some years ago I found them running entirely upon that plan. The Oxford furnace, situated at a town in New Jersey whose name I do not now recall, has carried on the same practice. At Boonton they roasted the magnetic ore in heaps. They took cordwood and laid it in rows lengthwise about three fee apart, covering a width of about 30 feet; they then bridged this over with a regular layer of cordwood laid close together, and on this the ore was piled and ranked back with the sides sloping at an angle of 45 degrees. In firing, in addition to the wood they occasionally put a little coke dust along with the ore, but the ore carried a good deal of sulphur, and the sulphur assisted in the roasting. The presence of sulphur in the ore was certainly part of the reason why it was roasted, but they would have had to follow this plan in any case because they could not run on magnetic ore alone. The furnace would run irregularly and give no end of trouble; besides, a proper quality of iron could not be made in this way. By roasting part of the ore they were able to make the quality of iron they required. They used coke for smelting. They made ordinary merchant bar; they had also a rolling mill and puddling furnace, and I think put the whole product of the furnace into merchant bar.

Mills.

Charcoal and coke irons are needed in Ontario.

From what I know of this country I would advise the making of both oal and coke iron. You have an ample supply of charcoal available in ountry. I think you could manufacture charcoal iron to greater advan- han coke here, because in the latter case you would have to import fuel. The trouble is there is often difficulty with stove manufacturers thers in using charcoal iron, owing to its tendency to chill. They pre- ke iron for ordinary purposes, for the manufacture of water pipe and s of that kind. At the same time for heavy castings there is no objec- vhatever to the use of charcoal iron; on the contrary, it is an advan- oecause it is a better iron. It makes a stronger and better finished plate coke iron, but when you come to make thin castings like stove plate is a little difficulty; there is some danger of getting a chilled casting, here is a difference in the grinding, etc. Mixing a small quantity of oal iron with coke iron gives a tougher plate, but to make it exclusively arcoal iron does not answer so well. If you want to make good malle- ron castings however you must have charcoal iron.

Cost of ore in Ontario as compared with Michigan.

I think charcoal iron can be made more cheaply here than in Michigan, se you can get your ore cheaper here. I am convinced of that. You et it in sufficient quantity, and I believe it will cost you a dollar a ton r ore than in Michigan. I figured on getting ore here at such a price looking into the question here a few years ago, and my calculations based on information I received from Mr. T. D. Ledyard, from my nowledge of the cost of ore at the mines north of Kingston, and from nation I got from other parties with whom I went thoroughly into the r. I came to the conclusion that the ore for the manufacture of iron would not cost us more than about $4 per ton, which is over $2 a ton than in Michigan. When I say $4 a ton I mean $4 for the ore ed to make a ton of pig iron.

Cost of roasting ore.

The roasting of the ore at Boonton costs 25 cents per ton. It may little more, but I understand it has been done for that in other . The cost depends entirely upon the facilities you have for obtaining ng material; where you have charcoal braize collecting about the ce it is a very easy method of getting rid of it. On roasting a large ity of ore in Texas we found the process cost us 25 cents per ton, t improved the ore some. We used charcoal braize, and had to haul ile and a quarter. We found it paid to roast the ore at the mines than to haul the ore to the furnace and roast it there, as we had no ies for roasting it at the furnace. When the miners were mining the ey would load it right into the carts and the carts delivered it on top of ln where it was roasted, thus saving one handling. When the waggons from the mine with the ore they took charcoal braize back, and so this ve found to be the most economical.

Competition of charcoal and coke irons.

The fact must be taken into consideration that charcoal iron made here come directly into competition with coke iron. Users of iron would it if they could get it at the same price, and possibly they might little more for it for some other purposes, but when I was investigating years ago I found that the malleable iron makers of Canada were coke iron, although supposed to be using charcoal iron. Some of mployés admitted to me the fact that they could not make malleable cast- qual to the United States castings for the simple reason that charcoal vas used in the United States and coke iron here. I consider that char- on could be made here more cheaply than at the Martel furnace, or in nsin, but supplies of coke iron from Great Britain would doubtless into competition with our charcoal iron.

Cost of producing coke iron.

With regard to the cost of producing coke iron here, I made some cal- ons three years ago, which might perhaps have to be modified a little but as near as my recollection serves me, the estimate I arrived at

Mills.

was $14.50 per ton, assuming we could get coke in duty free. Coke would cost us more here than at any point in the United States equally distant from the source of production, for the reason that we would not have return cargoes, unless we could get out our iron ore so cheaply as to be able to compete with the American ore and carry the duty as well. I am not favorably impressed with Nova Scotia coke. From what I have heard of it I believe it contains a large proportion of ash, running all the way from 8 to 20 per cent. I do not think it contains much sulphur. Pittsburgh coke contains from about 5 to 8 per cent. The worst Pittsburgh coke is about on a par with the best Nova Scotia, so far as I can learn. I do not think the Nova Scotia coke contains a higher percentage of sulphur than the Pittsburgh coke; I do not fancy that it does. But the cost of freight on Nova Scotia coke would be enormous. The magnetic iron mines north of Kingston are very much nearer to Pittsburgh than the lake Superior mines. The question whether you could send return cargoes of ore would depend largely upon the price which the mine owners would set upon the ore. If they were satisfied with a reasonable profit I see no reason why a trade could not be done. If they were exorbitant in their demands, it could not be done. I assume that a much larger quantity of iron ore would be raised if we could smelt it. If a start were once made I believe the business would develop, and that a much larger amount of ore would be mined than we could use ourselves. In that way we might be able to afford return cargoes to Pittsburgh and establish a regular trade back and forth. If once a mine was opened and thoroughly worked, it would pay to ship ore to the States in face of the duty.

Nova Scotia and Pittsburgh cokes.

"In the attempt to establish an iron industry here with a protection of $4 a ton on pig iron and a bonus of $2 per ton, the competition of British iron makers would have to be met. You would probably make at first a quality of iron only equal to a low grade of English iron. We have not the selection of ores they have; we may have better ore, but we have first of all to learn how to use our ores in order to produce the best quality of iron. It would not be safe to go upon any other ground than to count upon making at first an iron equal to the lowest grade of English iron, which at present commands a price of about $16.25 per ton here, duty paid. The cost at which I estimated we could make iron here was $14.50 per ton, which leaves us only $1.75 and the $2 a ton bonus, equal to $3 75 a ton altogether. Against this we must set the probability of the English furnace-masters putting the price of their iron down to somewhere about $13 per ton, which they can do. They would, I believe, make a push to meet the competition of iron made here, and they would even sell their iron at a loss at the start with a view of crushing the industry out. In order to make the undertaking a success we ought to have about $2 a ton more duty, and the duty on scrap iron ought to be made the same as upon pig iron. The present duty on scrap iron is only $2 per ton.

Protection against British iron makers.

"Another point is this: if we want to establish a large iron industry, something like the Pittsburgh industry, as we certainly can do if we set the right way about it, we must get a chance to make steel rails, which are now admitted free of duty. I would advise putting a duty of $6 a ton upon iron. I think it is $12 a ton in the States. But the removing of steel rails from the free list and the placing of the same duty on scrap iron as on pig are the most important things. It might be we could get along if we were saved from competition with scrap, which coming in at a duty of $2 a ton supplies a large proportion of the demand. I was talking to Mr. James Worthington of the Bolt and Nut Works a few days ago, and he said there was a large amount of scrap coming into the country. I would propose to put the duty on scrap iron up to the duty on pig, or near that figure. I think we ought certainly to manufacture all our own iron. If rolling

The trade in steel rails.

Low duty on scrap iron.

Mills.

mills for the manufacture of round and square iron and iron of various kinds, as well as steel rails, were established, one would help another, provided the duties were equalized; if for instance the duty on merchant iron were not so low as to partly counteract the duty on pig. Of course if the English manufacturers found themselves unable to send their pig iron they would send their bar if they could get it in cheaper than pig, and the result would be to hamper us again. It would be necessary to make sure that we had sufficient protection against that as well.

The uncertainty of protective tariffs.

"There is another serious difficulty in connection with the proposal to establish an iron industry here, and I do not know how it is to be met. It is the feeling that exists amongst capitalists, both here and on the other side, that even if a sufficient duty were placed upon iron it would be liable at any time upon a change of Government to be removed or reduced, in accordance with the politics of the incoming party, and that capital invested in the iron industry would consequently not be safe. The question arises, What guarantee can be given to capital that such changes will not take place? Of course if the industry had once taken firm root in the country, so that a large proportion of the population were directly or indirectly interested in the maintenance of the works, the question would settle itself, but until a sufficient proportion of the people to make themselves felt in politics become interested in the maintenance of the industry, this difficulty will stand in the way. I have this very statement made to me by capitalists in the United States when speaking to them on the subject, not only in connection with iron, but as regards timber limits as well. Some years ago I was trying to sell some timber limits for a friend on the other side, amongst others to some Bay City and Saginaw men, but they would not touch them. They said 'We do not know the minute your Government will put an export duty on timber.' In the United States the Democratic party certainly favors a revenue tariff, but the iron industry is of such enormous magnitude that I believe if the Democratic party were to take the ground squarely and say 'We are going to admit iron free,' it would simply put them on the shelf forever. They would have no chance at all. I am aware that at the last election the Democratic party adopted the plank of tariff reform, not specifying particularly a reduction of the iron duties, though these duties were widely discussed, and it was pointed out by Wells and others that they were a heavy tax on the producing classes of the United States. There is no doubt that the iron duties in the United States are too high, unnecessarily high. I think the position taken by the Democratic party affected the investment of capital to some extent, but the fact is I have been too much engaged in actual business to pay very much attention to politics. It is perhaps a curious conclusion to come to, but my impression is that the iron business in the United States would probably be in a more healthy state were it not for the high duties. So far as this country is concerned, the great bug bear, the sticking-point, seems to be the fear entertained by capitalists that a protective tariff might not prove a permanent one.

"There was an observation made to me the other day to the effect that the capitalists who had money invested in the industries of this country and who were developing its resources were chiefly Conservative in their politics, and that on the other hand the capitalists of the Liberal party had carefully abstained from putting their money into manufactures of any kind, but had invested it in mortgage and loan companies, in real estate, in shares of gas companies and in railway stocks and things of that kind. An observation of that kind shows what the impression is. I am not in a position to judge whether or not the statement is true, but the gentleman who spoke to me had every opportunity of being well posted."

SAMUEL J. RITCHIE'S STATEMENT.

Ritchie.

"I am interested in iron lands along the line of the Central Ontario Railway and in all the copper and nickel lands belonging to the Canadian Copper Company, as well as in the lands belonging to the Anglo-American Iron Company and those formerly belonging to the Vermilion Company. I think there are a little over 70,000 acres of iron lands held by our Company in Hastings county; I am not sure of the exact acreage. This does not include the Coe Hill mine, in which I am not interested. The Central Ontario Railway was built for the purpose of developing this property. The first thing we did was to make a contract with Mr. Coe when we purchased the lands now represented by the Coe Hill Mining Company, 14,000 or 15,000 acres additional, to build a railroad up to those lands and develop them. The railway was built from Trenton northward wholly and solely to operate and develop the iron interests there. We constructed ore docks at Weller's bay, and so far as transportation went we had all the facilities for developing and carrying the ore. We carried on operations at Coe Hill for two or three years, and got out eighty or a hundred thousand tons of ore; I do not now recollect the exact quantity The ore went principally to Cleveland, where it was remelted by the Cleveland Rolling Company. The results were satisfactory until the ore began to develop sulphur. There was very much less sulphur in the ore at the surface than farther down, so that not much was thought about it for the first cargo or two. The ore was rich in iron, carrying about 65 or 66 per cent. This mining was done in 1883 and 1884. We discontinued operations because of the sulphur, which rendered the ore unsaleable. There is a large quantity of ore lying there now. An attempt was made to roast it in the form in which it was mined, in coarse lumps, and the result was that only for half an inch from the surface was the sulphur driven off. The ore was not very dense. At that time the practice of breaking ore for the roast heaps was not adopted to any extent in the United States. There were furnaces where the ore was roasted, among others the furnace known as the Taylor & Langdon, but they were only adapted to treat the ore in a small and rather expensive way. From my explorations I am satisfied that there is any quantity of iron ore of this grade—containing more or less sulphur—in the district I am speaking of. I had Mr. Bolger make a survey for the railway, and in his report he states that for a distance of seventeen miles on a portion of the line immediately north of Coe Hill the compass was utterly useless; iron seemed to be present in mass all through the country. There is no doubt about the extent and quantity of that class of ore, such as could not be utilized then, but is now valuable when treated by the concentrating process. I did not find any red or brown hematite ore there.

Central Ontario Railway built to develop iron ore properties in Hastings.

Ore of the Coe Hill mine rich in iron, but high in sulphur.

Processes for cleaning and concentrating ores containing sulphur and phosphorus.

As to the concentration process, a machine has been patented by Lovett & Finney of Chicago which I have seen in operation at various places, and which I believe to be a great success. I have watched the machine in practical operation at a place in New Jersey where it is operated by the firm of Hecksher & Sons of Philadelphia. They were running it there on a very lean ore; magnetic of course, as it is no use for any other kind. It is a magnetic separator, and in my opinion is adapted to treat the Coe Hill ore. Washing the ore is an additional process after treatment in the magnetic separator. This machine combines the two processes; you can of course run it without the water, but the ore is much improved by adding the water, because it takes out nearly all the phosphorus. This machine reduces the ore to a fineness of about 10 or 15 mesh. I had a large model of it constructed and brought to Trenton, and had about half a ton of ore crushed to about 15 mesh size, and put through several hundred pounds in the presence

ut a thousand people during the ten or twelve days we were there. A
ne running with a 48 or 50 inch belt will run through five or six tons
d ore an hour. It gives an ore practically free from phosphorus. Of
e where sulphur is in chemical combination with the iron the machine
ot take it all out, but the experiments I have made show that we can
that sulphur off with a low degree of heat in about half an hour after-
The ore varies with respect to the way in which the sulphur is com-
with the iron. Sometimes it is found in chemical combination and some-
in mechanical combination; it is not a serious matter whichever way it
t one of the mines on the Hudson river they have been able to
phurize the ore at a cost of from 9 to 13 cents per ton after the mechani-
ocess has been gone through with, leaving it free from these impurities at
of 20 cents per ton. The whole process, concentrating and desulphuriz-
ight cost 40 or 50, or perhaps 60 cents for a ton of concentrates. That
give an ore free from sulphur and phosphorus and containing about
70 per cent. of metallic iron, and would enable us to use the
product of a mine instead of only half or two-thirds of it as you now
d thus make a great saving in the cost of mining. Edison is treating ore
sfully containing only 18 per cent. of metallic iron. There is also a sav-
freight charges when transported; the freight rates are lower, as it does
jure a boat or a car any more than a load of wheat. Furnacemen used to
at a charge of this concentrated ore would choke a furnace, but they
got over that nonsense now. The Bethlehem Iron Company are produc-
e finest steel in the world, and they tell me that they can use 50, 60, or
5 per cent of the fine ore. They make an offer to buy all they can get.
e a correspondence with them which reads as follows:

Ritchie.

'BETHLEHEM, PA., October 17th, 1891.

R. P. LINDERMAN, President of the Bethlehem Iron Company, South
ethlehem. Pa:

EAR SIR,—I am interested in a large amount of iron ore along the line
Central Ontario Railway in the Province of Ontario. Your Company
so made quite a large investment immediately upon the line of this rail-
The larger portion of the ores in which I am interested are not market-
the form in which they are mined from the ground, owing either to
ct that they contain too much sulphur, or that they are too low in
ic iron. For these reasons the mines have not been worked for the last
ears. I have thought that the new method of concentration and separa-
y the magnetic process would afford a solution of these difficulties, but
rged upon me that fine concentrates cannot be successfully used in the
e, and that there is therefore no market for this kind of ore. I would
ore be greatly obliged to you if you would give me your experience in
r to the following questions:

Concentrated ore smelted at South Bethlehem.

st. Have you been using, or are you now using, fine concentrated ore
r furnaces? If so, are the results obtained from it as good and favor-
s those obtained from coarse or lump ore?

nd. What percentage of the whole charge in the furnace of this fine
you use, and how high a percentage do you think you can successfully

rd. Do you manufacture any pig iron from ores which contain any con-
ble percentage of sulphur? If not, do you purchase pig iron from par-
ho do make it from ores which contain sulphur? If so, who are the
s who make pig iron from sulphurous ores? How much sulphur do the
ontain as mined from the ground, and which are afterwards smelted
he pig iron purchased by you?

Ritchie.

'4th. Does the pig iron made from these sulphurous ores contain any sulphur, and can it be used in the manufacture of Bessemer steel, and is it so used by any considerable number of Bessemer steel manufacturers?

'5th. Would you be willing to purchase any large quantity of fine concentrated ore? Very truly yours,

(Signed) S. J. RITCHIE.'

'THE BETHLEHEM IRON COMPANY,
'SOUTH BETHLEHEM, PA., Oct. 17th, 1891.

'Mr. S. J. RITCHIE, Akron, Ohio:

'DEAR SIR,—Answering your letter of the 17th inst, I beg to reply to the several questions that you ask me as follows:

Percentage of concentrated ore smelted in the Bethlehem furnaces.

'1st. We have used and are using a certain percentage of fine concentrated ore in our blast furnaces; the results, so far as I am aware, are as good as those obtained from coarse or lump ore.

'2nd. The highest percentage of concentrated ore which we have so far used in our charge is about 50 per cent., but I see no reason why a higher percentage might not be successfully used. If the ore is low enough in phosphorus, so that it need not be reduced too fine to eliminate that element, I see no reason why we should not use as high as 75 per cent., or possibly more.

'3rd. We do not manufacture any pig iron from ores which contain any considerable percentage of sulphur; we do however purchase pig iron from parties who do use ores which I understand contain in their natural state quite a high percentage of sulphur—the ore referred to is the Cornwall ore. I cannot say how much sulphur these ores contain as mined from the ground, but have no doubt that the parties who use this ore would willingly give you this information.

'4th. The pig iron made from Cornwall ore contains some sulphur, but not sufficient to prevent its being successfully used in the manufacture of Bessemer steel, and it is so used by the large steel rail mills in the east.

'5th. Whether we would be willing to purchase any large quantity of fine concentrated ore would depend almost entirely upon the price and quality.

'Trusting that the above will satisfactorily answer your questions, and holding myself ready to give you any further information that I can, I am, Yours truly,

'(Signed) ROBERT P. LINDERMAN, President.'

'I have also a letter from Thomas Edison on the same subject, of which the following is a copy:

'ORANGE, N. J., November 26th, 1889.

'S. J. RITCHIE, Esq, New York City.

Edison's magnetic separator.

'DEAR SIR,—Replying to your letter of 21st instant, in regard to refining ores in Canada by means of my Magnetic Ore Separator, I beg to answer your queries categorically as follows:

'1st. What would be the approximate cost per ton of the ore as mined from the ground, for crushing and separating the iron contained in it from the silica or other foreign matter, by your process? A. Actual cost, 62 cents per crude ton.

'2nd. How much iron will you be compelled to waste in the rocky matter which you separate from the iron? A. 1½ to 2 units of original ore.

'3rd. How high a grade of ore can you produce from an ore carrying, as mined, say forty per cent. of metallic iron? A. Average 65 per cent.; by refining concentrates, cost ten cents per ton, 68 per cent.

Ritchie.

'4th. What would be the difference per ton in cost of producing an ore that would yield sixty per cent. and one yielding sixty-eight per cent.? A. Ten cents.

'5th. To how low grade of ore can you use the whole product of the mine, without throwing any portion of it into the waste heap, by sorting or separating it into second-class piles? A. It will pay to use as low as 20 unit ore.

'6th. Allowing, as is usually the case in all magnetic ores, that thirty per cent. of the ore mined is thrown into the waste heap, these heaps usually carrying about forty per cent of iron, how much of the cost per ton for mining can you save by grinding up the whole amount mined and saving all the ore contained in it? A. Ordinarily, mining costs $1 per ton; if you take everything down to twenty unit, cost generally will be 50 to 60 cents.

'7th. Can you lower the phosphorus contained in magnetic ores? A. We can reduce the phosphorus 75 to 80 per cent.

'8th. Will the fine ore which is obtained by your crushing and separating process be worth as much per unit of iron when delivered at the furnaces as the lake Superior Bessemer ores containing an equally high percentage of iron? A. Yes, so the iron men say, and worth more if we go to 68 per cent.

Cost of treating ores by magnetic concentrator.

'9th. Calling the mining of the Canadian magnetic ores one dollar per ton, the railway and lake freight one dollar and sixty cents per ton, the duty seventy-five cents per ton, seventy-five per cent. of the ores carrying fifty-five per cent., and thirty per cent. carrying forty per cent.: can you deliver this ore in Cleveland at as low a price per unit of iron as the lake Superior ores can be delivered at same place, the lake Superior ores being subject to a royalty of fifty cents per ton and the Canadian ores being free from royalty? A. About the same. Can on above assumption of costs deliver a 68 per cent. ore at Cleveland for $5 per ton, sure, against a 65 per cent. ore from lake Superior.

'10th. On what terms will you erect, at your own expense, upon the line of the Central Ontario Railway at the mines belonging to the Anglo-American Iron Company in Canada, the plant for which you have now completed the plans, having a capacity for treating one thousand tons of ore per day? A. I will put up mill and refine for 70 cents per crude ton to 65 per cent., and refine concentrates at ten cents per ton, to bring it up to 68 per cent.; capacity 1,000 tons daily, no less. You may purchase mill at end of two years on twenty per cent. earnings being capitalized at par.

'11th. On what terms will you put up a similar plant having a capacity of 2,000 tons per day? A. Sixty-seven cents.

'12th. How soon can you have this plant in condition to work? A. Beginning May 1st, 1890, 90 working days.

'13th. Do you think it practicable and advisable to put up a blast furnace for smelting this ore, and a steel plant for the manufacture of steel, in Canada? If so, what measures are necessary to be adopted by the Dominion Government? A. Yes; protective tariff and a bonus for eight years.

'14th. Are you willing to become interested in the smelting and manufacturing of iron and steel in Canada? A. Yes. Very truly yours,

'(Signed) THOMAS A. EDISON.'

"I have a similar letter from the parties who treat the Hudson river ores, offering to either put up or run a plant with a daily capacity of 2,000 tons, and to reduce the sulphur down to two-tenths of one per cent. I have had further correspondence with Edison, and he offers to put in a plant capable of treating 2,000 tons per day. His process does not differ very materially from the one I have been speaking of. He uses a different kind of crusher; that is about the extent of the difference. I do not think they can use the entire charge of the furnace of this fine ore; I think they would have to use some coarse ore with it.

Ritchie.

"Unquestionably a good grade of iron can be made from the magnetic ore only. The best Norway iron is made wholly from it. It is not at all necessary to mix the magnetic ore with red hematite to secure the best results.

Magnetic ore in furnace practice.

Possibility of making coke iron in Ontario, in combination with nickel.

"I want to say that if I had not been hindered by my own associates I could have had a plant erected at Trenton, at which the ore from along the line of the Central Ontario Railway would have been treated and mixed with the nickel from Sudbury, and Canada would today be supplying the Bethlehem Company with the nickel and iron to make the plates used on the American war-ships. I have no doubt at all that iron furnaces could be successfully established in this Province. The fuel for them to use would be coke; the distance is shorter from the place on the Rochester and Pittsburgh Railroad where coke is made than it is to Joliette, Illinois, by a hundred miles. I think this material could be taken into the United States free under the McKinley tariff, which levies the duty on the article of chief value. Suppose you make something in the way of matte and send it in the form of pig iron, I think it would go in free under the McKinley Act. Say the pig iron were worth $10 and the nickel $16, the whole would go in free, because nickel is free. This was the intention when framing that provision in the tariff law.

Demand for nickel steel.

"I think the iron industry can be most successfully established in this country in combination with the nickel industry. I do not see how it could live here alone. There would be no use in anyone trying to send iron from here to any other country, whereas nickel steel could be sent to England or the continent, or anywhere in the world. There is no question that the demand for nickel steel will be a large and permanent one. I can quote what Sir James Kitson told me the last time I saw him; he said that every boiler in Her Majesty's war vessels would be superseded by nickel steel boilers, and that every plate upon Her Majesty's ships would be superseded by nickel steel plates, and this not only for first class, but even for second and third class vessels Sir James is ex-president of the Iron and Steel Institute. There is no doubt that nickel steel must be preferred for any purpose where great strength, elasticity and resistance are required. There is a market in the United States for this ore when treated in the way I have described, and the difference between the freight you would have to pay, for instance, from anywhere on the Central Ontario to points east of the Allegheny mountains and the freight you would have to pay from lake Superior ought to more than offset the duty. Canada ought to have a large market of her own. She has upwards of 13,000 miles of railway—a larger percentage of mileage per head than the United States—and there is no reason why she should not produce the highest grade of material for all her locomotives, cars and car-wheels which she now buys of Krupp. Krupp has got to go to Africa for his ore and ship and haul it by rail. If he gets any nickel he must go to New Caledonia or Canada for it. There is no reason why all these things should not be manufactured here. There is no such difference in labor, fuel or tariff as to prevent it. I am certainly of opinion, from observation in my own country of such towns as Pittsburgh, Chicago, Cleveland, Reading and Bethlehem, that by the establishing of various branches of the iron industry you create a local market for pig iron, and in that way you put the industry on a better basis. I do not know any country that ever got rich by selling raw material and buying manufactured, and I do not think that Canada will prove an exception. She needs to manufacture for herself; she cannot sell grain from the farm and buy manufactured articles, paying 30 or 40 per cent. duty on them, and prosper very well

Local market for the product.

The coke supply no hindrance.

"There is no reason in the world why the iron industry should not be established in Ontario. The Illinois manufacturers haul their coke over five hundred miles; you do not need to haul yours over three hundred. These companies do not have any return cargoes; the cars in which the coke is brought go back empty. No grain or anything of that kind is shipped in them. The cars are owned by the companies themselves. Train after train comes to the Illinois Steel Company with coke, and goes back empty. The copper mines at Butte, Montana, get their coke from Connellsville, and pay $18 or $19 a ton for it. I have not the figures with me which would enable me to say what amount of freight the establishment of such an industry would contribute to the railways, but I can say this that if the mineral business were taken away from the Pennsylvania system of railroads it would bankrupt it in four months, and the case is similar with all the railroads in the United States. The only wonder is how the roads here can live without such a business at all.

Ritchie.

"The iron business would afford employment for all classes of labor, from the most skilled artisan to the common navvy. A great number of the iron workers in the States are paid high wages, higher than any form of labor employed in Canada. Labor in the iron and steel mills and iron furnaces of the United States is better paid than labor in the mines or on the farm—more than twice as much as farm labor.

Employment of labor.

"For the manufacture of nickel steel it does not matter much whether you have protection or not. Steel rails I think now come into Canada free. You have no industry to protect, if protection pure and simple is what is aimed at. What you want to do here is to produce an article which you can not only sell at home, but export it abroad and keep your balance of trade right. If you make nickel steel you do not need to swap it for anything. You could not sell iron alone in England; carrying coals to Newcastle would be an easy task compared with that. I do not know how they could manufacture nickel steel more cheaply in England than we could here. They cannot manufacture for nothing there any more than we can here. Their coke costs as much as your coke would cost. When I was over there last, coke was higher a good deal than it was in the United States. I think that there is little doubt you could lay down coke here just as cheap as the majority of manufacturers in England get it. I do not think there is anything lacking now to enable the industry to be established, since a process has been invented to treat such ores as you have here. If you were going in, depending wholly upon the ore as it is taken from the ground, it would be another story. There is plenty of ore where there is no railway. Between the end of our railway and the Northern there are large deposits of ore containing no sulphur. But as you are able to treat the entire output of the mine by this process and get a superior class of ore, especially after roasting it, it is not so essential that a first class ore be provided by nature as it used to be.

No protection needed to establish a nickel steel industry.

"I think if your moneyed men who have invested so largely in loan societies, etc., wish to protect their investments they cannot do better than set about establishing this industry. No country can ignore such a natural storehouse of wealth and expect to prosper. Compare the Southern States of today with what they were before the war, when they used to purchase everything with cotton, even the bacon they used, from the north, and see what a change has been brought about by the development of their mineral resources. Lands around Birmingham that were offered to me for fifty cents or $1 per acre could not be bought now for $5,000 or $10,000 per acre."

Why capitalists are interested in establishing the industry.

CHARLES J. PUSEY'S STATEMENT.

"The facilities which the Haliburton and North Hastings district affords in the abundance and variety of ores, the accessibility of limestone for flux, and the large quantities of good hardwood for charcoal, would in my opinion enable the manufacture of pig iron to be carried on there to greater advantage than at any other point. The advantage of making charcoal iron over coke or anthracite iron is that it circulates every dollar which enters into its manufacture among the people of the country, while in the case of coke or

Pusey.

Pusey.

anthracite iron about one-third of the entire cost is sent out of the country for fuel. I think that is an important point. We have estimates made by Mr. Witherow of Pittsburgh, now dead, of the cost of making charcoal pig iron at Snowdon. Taking the cost of mining the ore, the cost of wood and the expense of making it into charcoal, Mr. Witherow estimated the cost of manufacturing charcoal pig iron there at about $10 per ton. On the basis of the data I gave him he said he would undertake to make it at that figure. I gave him the market value of the cordwood delivered at the railway, the cost of other supplies, the analyses of the ores and all other data he required in making his estimate. It was a little less than $10 per ton. The exact figures as given by me in the report of the Commission on the Mineral Resources of Ontario were $9.08 per ton, and I see no reason for changing them."

Advantage of making charcoal iron over coke or anthracite iron.

Cost of production.

JAMES CONMEE'S STATEMENT.

Conmee.

"There does not appear to be any prospect of the ore on the Canadian side being worked to any great extent at present. If iron furnaces were built there is no doubt the ore would be worked; in fact Mr. Caldwell offers to contract for the delivery of 25,000 or 50,000 tons or more of ore to a furnace if one were erected. I think some encouragement is needed for the erection of furnaces; it would require capital, which the people of Algoma have not got. I am aware that there is a tariff of $4 and a bonus of $2 per net ton on pig iron. This should be a considerable inducement, but the condition which is attached to the bonus is that the iron must be produced from Canadian ores. In our part of the Province there are no Canadian mines producing ore, and so the difficulty of complying with this provision is quite serious. We cannot get a furnace built without a guarantee of ore to supply it, and we cannot induce people to mine without the guarantee of a smelter being erected. If capitalists could be got to agree together to mine ore and erect a furnace as well, it would seem to be a feasible way. I think this result might be brought about if the Government was to make a loan to a good, substantial company, which could show that it was possessed of the business experience and ability to carry on this class of work, or guarantee its bonds for a certain amount. The Government could hold the company's property as security, and in this way furnaces might be established and mines opened, and the Government would be secured for the risk. I do not think there is any necessity for the Government to assist in the working of the mines; if they would assist in the establishment of a furnace it would create a market for the ore, and the mines would certainly be worked. I do not propose that the Government should make the company a gift of the amount, but that they should loan it; or they might guarantee the company's bonds for twenty years, taking a first lien on the property, and if the company failed to pay the bonds the Government would have the property as an asset. I think this would enable the company to secure the necessary capital and make the undertaking a success. I do not think there would be any difficulty whatever in getting men to undertake the construction of a furnace if these inducements were offered. I feel quite sure that good men could be got to go into the business if they were enabled in some such way to secure the capital on easy terms. But if the Government would give a direct bonus it would be perhaps a greater inducement. I would consider $100,000 a good bonus, and would prefer it in a lump sum in cash; or, say, when the works were partly completed $25,000 might be advanced, when wholly completed and put in operation another $25,000, when 100,000 tons of ore were raised and treated a third sum of $25,000, and when a similar quantity of ore was put through the remaining sum of $25,000 might be handed over, spreading the payment of the bonus over the space of two years. I think a furnace started with sufficient capital in the hands of good men would secure

Some encouragement needed for erection of furnaces.

Conmee.

The market for steel rails.

The chance of Canadian ores in the United States market

depends on economic handling.

Interdependence of mining and smelting.

nadian market. There is no duty on steel rails coming into Canada ilway purposes at the present time. There is a duty on light rails, such used for tramways, but none on standard railway rails. If our mines roducing sufficient ore, and we had furnaces and rolling mills in opera- nd were unable to get reciprocity with the United States, it might be o put a duty on steel rails; but I am not at all in favor of protective . I do not think it would be wise to put on such a duty at the pres- ne, or until our mines were further developed. I would say this, that United States continue to charge a duty upon rails manufactured in ountry Canada should do likewise; but what would encourage the ping of our mines more than any protective duty would be free entry he United States for our iron ores. We import steel rails from the d States in considerable quantity. As a general rule the English rails e cheaper, but at times we can buy rails from American manufacturers ter advantage than from the English. About one-third of the rails own on our road were American; we could get them cheaper at the han we could English rails. Railway companies are often in a hurry ils, and they can get them from the American manufacturers more y than from the English, there is so much delay in getting rails across tlantic. For this reason the preference is sometimes given to the ican rails, even though they cost a little more I think the C. P. R. rought a good many of their rails from the States, but they have got supply mostly in England. If a duty were put on rails I suppose it have to apply to all countries. I think if our mines were developed e had furnaces started we could compete with either England or the d States, and should not ask any duty. We have all the raw material, e have the advantage of not requiring to pay freight; that ought to be tion enough. I think Canadian ore could be shipped to the States at t prices, if there were no prejudice against it; it would depend upon uality of the ore offered. I do not consider the 75 cents a ton duty on ing into the States prohibitive at all, owing to the fact that our ore near the surface and can be mined very cheaply; but to handle ore ompete with the Americans it would have to be handled on the same that they handle it. They have the very best of railway facilities; et their ore carried to the water's edge for less than a dollar a ton lway transit. They have the benefit of the return cargo, but we would that too. They have ore docks, over which they handle their ore just in is handled in an elevator; a vessel is loaded in two or two and a hours, and to give vesselmen and shippers the same facilities would e the expenditure of a very large sum of money in the construction of ys, ore cars, ore docks, harbor facilities, etc., to enable the mines in io to supply ore to the American market. I think the setting up of ces in our own country would soon be an accomplished fact if the l were obtainable, and these together with the facilities that I speak of ipping, etc., would no doubt lead to active mining. I believe there be a ready market for Canadian ore in the States, because as a rule richer and better than the American ore. That would be a good begin- or the mining industry, but I think the most important thing of all is stablishment of smelters to supply iron for our own market. It would e double the capital to work the mines and operate the furnaces if the company undertook the whole work, but I think if a smelting furnace be got in operation the question of mining would settle itself. I have ubt those who own ore would be glad of an opportunity to place it in arket. It would require still further capital to erect rolling mills for anufacture of rails, or plates, or bar iron, but it seems to me that if a er were established to produce a good quality of charcoal pig iron all other things would follow; private capital would be introduced to take

Conmee.

hold of and establish rolling mills. I think a charcoal furnace would be the most desirable. No doubt a grant of timber by the Government for the purpose of making charcoal would be an assistance, but what is wanted is capital, something to induce capitalists to go into the business and erect furnaces and the whole plant necessary to produce pig iron. A guarantee of bonds to the extent of $200,000 would go a long way towards furnishing the means to establish the works, or a bonus of $100,000 would be of very great assistance. I think Port Arthur or Fort William are the only places where the necessary facilities can be had for the erection of the works, with convenient supplies of ore and fuel. There is a great deal of pitch pine there, as well as spruce, tamarac and birch, and I understand these are all good for making charcoal. The Port Arthur, Duluth and Western Railway goes through forest for part of the way, and there is plenty of timber within 20 or 30 or 40 miles of Port Arthur of the kinds I have mentioned. These woods are light as compared with maple or beech, but I think about fifty cords could be cut on an acre. The timber has a thrifty growth, the trees stand close together, and while each tree would not cut as much as maple or beech the yield per acre I think would be larger. I have had no experience myself which would enable me to say how many cords per acre can be cut, but I have asked the question of Captain Hooper, who was operating the Beaver mine and cleared a great deal of land for the wood, and he told me that from 45 to 50 cords per acre could be cut; a great deal of it was poplar, but the other kinds yield about the same. Then there is another point in favor of Port Arthur and Fort William in case a coke furnace was built. Vessels taking up coal or coke could carry east pig iron, iron ore or grain, and with return cargoes assured we could depend on getting the cheapest freight rates."

Advantage of Port Arthur and Fort William as seats of the industry.

THOMAS D. LEDYARD'S STATEMENT.

Ledyard.

"I think the proper fuel for a furnace situated in Toronto would be coke, which could be brought here just as cheaply as it can to Chicago, and perhaps a little more cheaply. There should be plenty of room in the market for the production of a furnace having an output of 100 or 150 tons a day. Our investigations led us to believe this to be the case. I have an estimate of the cost of making pig iron by Mr. Henry Kelly, who came over here independently to see my own and other properties, and who is thoroughly posted in mining. He is a member of the Society of Accountants, Philadelphia, and has been employed by some of the largest works in the United States to put their books into proper shape, and in this way he has seen the working of many furnaces. His statement is as follows, and was written after examining the properties in Belmont and Snowdon:

Coke fuel advised for a blast furnace located at Toronto.

'Toronto, July 19th, 1892.

Estimate of cost of production.

'Dear Sir,—The following is my statement of the cost of making Bessemer pig iron in this city, based on my knowledge of the cost of manufacture in Pennsylvania, U.S.A.: Ore at $3.50=$5.78; coke at $4.50=$4.50; limestone at 75 cents=.38. Total cost of materials, $10 66; labor, making, $1.31; labor, repairs, .09; incidentals, .81; salaries, office, etc., .35. Total, $13.22. Yours truly,

Henry Kelly, Accountant.
Philadelphia, Pa'.

"Mr. Kelly was a special expert for the Cambria Iron Company of Johnstown, Pennsylvania, and other companies.

"One thing has operated against the establishment of the ironmaking industry in this Province, namely, the fact that those who wished to engage in it would have to provide all their own ore; while in the United States, for instance, they can go into the open market and buy at any time and in any quantity at the market price. There is no ore ready to be delivered in Ontario because there are no mines, and as a consequence the starting of the iron industry here would involve the risk and expense of mining the ore as well, which is a very serious consideration when you take into account the large amount of ore that should be on hand before a furnace can be started. For this reason a much larger amount of capital is required than if you were beginning a similar enterprise in the States, where you can buy ore from time to time as it is needed. For instance, take a furnace that would turn out 150 tons of pig iron per day, which would be about 45,000 tons a year To provide a year's supply of ore amounting to fully double that quantity, or say 90,000 tons and pay for it beforehand at say $3.50 per ton, would require the outlay of a very large sum of money—upwards of $300,000. If our mines were first opened and the product exported for a time to the United States, I believe the effect upon the prospect of starting the industry here would be beneficial. I know that men who are moving in the latter direction at the present time are watching with much interest the operations of the Belmont company at that mine. I think an iron blast furnace could be established here even before the mines were worked to great extent if the Government were to give a bonus. Other people besides myself who know of iron deposits say that if there was a furnace in Toronto which would give a fair price for ore there would be no lack of ore, but you would have to go farther away. These properties are about 110 miles from Toronto, but I am told that there is no question of there being a sufficient supply of ore within 200 miles of Toronto. I would not regard 200 miles a long distance to carry iron ore; half a cent a ton per mile is the rate United States railways charge, and at this rate the cost of bringing it 200 miles would be only $1 per ton. A furnace would give a local market for ore and would use ore that could not be exported on account of not being rich enough in iron, such as hematite running from 45 to 50 per cent. I think Toronto would be as good a place for a coke furnace as any. Besides being a convenient spot at which to assemble the materials, it is a good distributing centre, which is a great advantage. Enough iron is used in Toronto and the country for which Toronto is the distributing point to support a furnace of this kind. I would certainly regard it as a very decided advantage to locate a furnace where there is a considerable local consumption of pig iron. If I were to erect a charcoal furnace I should place it near the mines. The trouble with a charcoal furnace is that it would give you only one brand of iron, and however good it might be the users of iron want a mixture. In the making of malleable castings charcoal iron is the best by all odds, but I am told that even in making carwheels they want a mixture. All the capitalists with whom I have conversed were favorably disposed towards the erection of a furnace; they thought it was a good enterprise and ought to pay very well, but, from its being to some extent an experiment with a good many risks attached, they felt that they could not get local subscriptions for stock unless the Ontario Government also took some. It was a common opinion among our own people here that our ores were not good, but now that this American company have taken hold of the Belmont mine and are shipping the ores to Pennsylvania they may change their mind. The result of my investigations and negotiations was that we could not get any local capital interested in the scheme without an additional bonus which was looked for from the Ontario Government, and if this were given to a sufficient amount they would subscribe. I got this further promise, that if Toronto people subscribed half the required capital the other half would be furnished by American capitalists. The bonus paid by the Dominion Government upon pig iron manufactured in Canada is now $2 per ton, and will remain at that figure until 30th June, 1897. The $2 rate took effect, I think, on the 1st of July last year, and is

A hindrance to iron making in Ontario, which demands large capital to start the industry

hence a reason for Government aid.

A furnace would create a local market for ores.

Considerations which influence location.

Capitalists want more bonus.

Ledyard.

payable on the net ton of 2,000 lb. The customs tariff on pig iron is $4 per ton, so that there is a total bonus of $6 per net ton, which ought to be enough. The bonus asked from the Ontario Government is $2 per ton, to be continued for ten years."

THE IRON INDUSTRIES OF ONTARIO.

It would be a mistake to say or assume that our Province is without an iron industry. A metal having such a wide range of uses as iron could hardly be excluded from the industrial arts of any civilized country. Ontario can show a list of some variety, even if the figures do not make an imposing array. The statistics of the last census are not yet available, and therefore the table which follows has been compiled from the census of 1881. It gives the number of establishments in which iron is used as the raw material of manufacture, the number of workers employed in them, the amount of wages paid in the year for labor, the value of the raw material used, and the value of the products of the works.[1]

Statistics of the census of 1881 for iron and steel works.

Industries.	Establishments.	Employés.	Wages.	Value of raw material.	Value of products.
			$	$	$
Agricultural implements.	141	3,201	1,130,475	1,613,093	3,928,411
Blacksmithing.....	3,586	6,026	1,409,322	1,331,730	3,906,509
Boiler works...........	17	260	82,492	151.700	271,833
Car and locomotive works	12	1,622	637,460	1,224,826	2,081,702
Cutlery	1	67	26,000	44,000	100,000
Edged tool works.......	13	337	144,030	164,280	411,550
Engine works.	8	560	216,300	452,900	808,000
Fire-proof safe works ...	2	82	42,500	32,000	88,000
Fittings and foundry work in iron, brass, lead, etc.	75	1,084	396,021	675,458	1,388,805
Foundry and machine works..............	342	5,021	1,867,977	2,219,798	5,839,467
Gun making...........	24	38	16,611	8,610	34,095
Lock making	1	95	13,000	10,000	50,000
Nail and tack factories..	2	80	35,000	120,000	185.000
Rivet factories..........	3	27	10,000	15,000	72,000
Rolling mills	1	225	100,000	250,000	400,000
Saw and file cutting.....	10	165	69,100	147,330	277,400
Scale factories	1	20	7,000	16,000	35,000
Screw factories	1	66	13,700	20,809	50,960
Sewing machine factories	7	604	215,944	170,672	517,246
Spring and axle factories	4	139	46,500	118,300	178,500
Steel making	3	110	33,967	68,760	172,150
Steel barb fence factories	1	3	1,200	4,000	12,000
Tin and sheet-iron works	670	2,049	582,024	994,654	2,178,629
Wire works............	2	19	6,900	7,500	22,000
Totals	4,927	21,900	7,103,523	9,883,420	23,009,257

Comparison with other manufactures in the Province.

Compared with all manufacturing industries of the Province for the same census year, the foregoing table shows that the iron industries were 21½ per cent. of all industrial establishments, that the number of workers to which they gave employment was 18½ per cent. of all workingmen engaged in manufactures, that the amount of wages paid to them constituted 23½ per cent. of the total wage earnings, that the value of raw materials used was nearly 11 per cent. of the total of raw materials, and that the value of finished product was 20 per cent. of the value of all manufactures. These figures demonstrate

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[1] Bulletin No. 8 of the census of 1891, which gives numbers of establishments and of workers employed in them, shows that in some branches of the industry there has been increase and in others decrease during the last decade; but the classification is not sufficiently complete to permit of a full comparison being made, and no statistics have yet been published of wages, materials or products for the last census year.

Comparison with U. S. centres of production.

nportant a part of the industrial life of the country is taken up by the s in iron; yet if comparison be made with some other countries it will nd to be a very moderate if not an insignificant part,—with Sweden lgium, for instance, or with the states of Pennsylvania, Ohio and Illinois. may be more instructive to borrow illustration from three or four of the iron industry instead of making a comparison by countries.

THE IRON INDUSTRY IN PENNSYLVANIA.

In the Schuylkill valley.

October of last year I attended the meeting of the American Institute ing Engineers held in the city of Reading in Pennsylvinia. Reading opulation of 65,000. It is situated on the Schuylkill river, off all the nes of traffic in the state; yet it is a hive of industry, and for more hundred years blast furnaces have been producing pig iron in the town e country tributary to it. In a paper read at the meeting of the te by the President of the Board of Trade the following statistics were of the value of iron manufactures in the city for the year ending Sep· 29, 1892 :

Reading.

Stoves	$ 659,000
Boilers and flues	323,000
Hardware, locks and butts	1,650,000
Pig iron, wrought iron, pipe and machinery	8,400,000
Iron beams, bridge work and steel	4,000,000
Bolts, nuts, rivets, etc	1,000,000
Total	$16,032,000

ese industries give employment to 6,850 people; but they do not e all the manufactures of Reading. Other lines of goods produced the same year, with their values, are shown in the following table :

Hosiery	$ 550,000
Boots and shoes	150,000
Silk and cotton goods	1,725,000
Rope and cordage	600,000
Fire-brick, terra cotta and glass	320,000
Wool and fur hats	3,000,000
Cigars	3,150,000
Total	$9,495,000

re than half of the whole population of the city, I was informed, is ted by its manufactures; and the value of iron products alone, it will rved, is seventy per cent. of the value of all the products of the iron ies of Ontario in the census year 1880.

Pottstown.

th of Reading about twenty miles, on the line of the Reading Railnd also upon the Schuylkill river, is the town of Pottstown. It has a tion of 15,000, and it is said that almost every workingman in the place oyed either in making or manufacturing iron. There are blast furnaces, works, boiler works, stove works, mill iron works, cut nail works, pipe orks and steel rail and plate works. The last named establishment was about thirty years ago in the interest of the Reading Railway Comnd after changing hands two or three times it is now controlled by nen organized as the Pottstown Iron Co., with a capital of $1,000,000. nt consists of a blast furnace which smelts Lake Champlain and ores high in phosphorus and silicon, producing 800 tons of pig iron ; three basic Bessemer converters, the largest of their class in the States; a mill for making fire-brick to line the converters; rolling or rolling boiler and other plate; nail mills, etc. Two thousand men ployed by this company alone, whose yearly earnings foot up $1,000,- one seventh as much as all the wages paid by all the iron industries ario in 1880 and this in one town of 15,000 inhabitants.

There are several other active manufacturing towns in the Schuylkill valley, above and below Reading, one of which is Birdstown, made famous recently by the construction in one of its iron-working establishments of the wire gun—which members of the Institute had the privilege of seeing in a partly finished state.

In the Lehigh valley.

South Bethlehem.

Less than fifty miles eastward of the Schuylkill is the Lehigh river, a tributary of the Delaware. From the gap at Mauch Chunk, where the Lehigh breaks through the Blue mountains, down to its mouth, this river is almost one continuous line of blast furnaces and iron works. Chief among these are the works of the Bethlehem Iron Company, with eight blast furnaces for smelting iron ore (Cuba red hematite, Elba specular and New Jersey magnetic—the latter treated by the Edison magnetic separators), a steel plant with four Bessemer and four Siemens open-hearth furnaces whose aggregate steel-making capacity is 915 tons per day, steel rail mill, and forging and machine shops for the manufacture of guns and nickel steel armor plate for the United States navy. These works give employment to over 4,000 men, and the ground occupied by them extends a mile and a quarter along the Lehigh river by a quarter of a mile in width.

In the Ohio Valley.

Allegheny county.

But the great centre of the iron industry of Pennsylvania as well as of the United States is in the western part of the state, in Allegheny county, whereof Pittsburgh is the chief town. In 1874 there were 11 blast furnaces in this county which produced in that year 143,660 net tons of pig iron, an average per furnace of 13,060 tons; in 1891 the number had increased to 26 and the production to 1,635,531 tons, an average per furnace of 63,289 tons. In 1874 there were also 42 mills and steel works in the county whose total make of crucible, Bessemer and other steels was 23,915 net tons, an average of 570 tons; in 1891 the number of mills and works had grown to 63 and the production to 1,542,921 tons, an average of 24,490 tons.[2]

Pittsburgh.

Further and more imposing evidence of the value of the iron industries of this great centre is found in the assessment rolls of the city of Pittsburgh. For the purpose of levying a business tax, every person or firm engaged in mercantile pursuits in the city is obliged to make each year a sworn return of the gross amount of business done, and the business tax is levied thereon. The following list shows the amount of such business in iron and steel for the year ending 31st March, 1893:

Iron and steel industries of Pittsburgh.

Atwood & McCaffrey, foundry,	$ 308,489
A. M. Byers & Co., iron,	875,832
U. Baird, Machinery Co., machinery,	130,000
H. L. Childs & Co., mill supplies,	215,000
Crescent Steel Co., steel,	420,000
The Harmes Machine Department, machinery,	100,000
The Shook Anderson Machine Co.,	120,000
Singer, Nimick & Co., iron,	1,063,339
S. Severance, spikes,	179,000
Smoky City Boiler Works, boilers,	100,000
The Birmingham Iron and Steel Co., iron and steel,	100,000
Charles A. Turner, mill supplies,	125,000
W. G. Price & Co., plumbers,	225,000
Pittsburgh Supply Co., oil well supplies,	525,000
Riter & Conley, boilers, etc.,	1,016,871
Joseph Woodwell & Co., hardware,	208,701
Neal Bros., iron and steel,	100,000
Oil Well Supply Co.,	300,000
McGinnis, Smith & Co., heating apparatus,	100,000
Apollo Iron and Steel Co., iron and steel,	100,000
Bovaird, Seyfang & Co., oil well supplies,	100,000

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[2] Report of the American Iron and Steel Association for 1891, p. 70.

Iron and steel industries of Pittsburgh.

Pennsylvania Tube Works, iron,	$1,982,040
Robinson Rea Machine Co., machinery,	600,000
The Kelly & Jones Co., steam fitters,	250,000
Bradley & Co., stoves,	100,000
Clinton Iron & Steel Co., iron and steel,	550,000
Frick & Lindsay Co., mill supplies,	100,000
National Tube Works, iron,	200,000
A. Garrison, Foundry Co., foundry,	515,735
Jones & Laughlins, iron and steel,	5,500,000
Wolff, Lane & Co., hardware,	278,486
Bindley Hardware Co., hardware,	600,000
Demmier Bros., hardware,	335,000
Carnegie Steel Co., (Ltd.),	9,582,328
Benny Bros., machinery,	150,000
Babcock & Wilcox, boilers,	200,000
Dilworth, Porter & Co., railway supplies,	1,500,000
Lyle & McCance, hardware,	127,000
Steel and Iron Implement Co.,	100,000
H. K. Porter & Co., locomotives,	437,620
Standard Mfg. Co., plumbers' supplies,	219,059
W. A Giles, engines,	100,000
Nease, McLain & McGinnis, hardware,	120,000
Brown & Co., steel,	800,000
McWhinney & Co., hardware,	200,000
H. Lloyd's Sons & Co., iron,	411,912
Mackintosh, Hemphill & Co., founders,	890,870
Joseph C. Lindsay & Co., hardware,	315,000
Logan, Gregg & Co., hardware,	600,000
James Rees & Son, engines,	161,046
Bissell & Co., stoves,	176,000
Singer Sewing Machine Co.,	100,200
Standard Sewing Machine Co.,	175,000
I. N. Scott & Co., agricultural implements,	200,000
Scoble & Parker, agricultural implements,	205,100
A. Speer & Sons, plows,	184,328
John Hall, jr. & Co., agricultural implements,	130,000
Consolidated Steel Co., wire,	100,000
Standard Underground Cable Co.,	621,901
Zug & Co., iron,	795,700
Schoenberger & Co., iron,	2,613,000
Howe, Brown & Co., steel,	100,000
S. Jarvis Adams & Co., foundry,	180,000
Jarecki Manufacturing Co., pipe,	125,000
Hainsworth Steel Co.,	1,000,000
Cold Rolled Steel Co., steel,	250,000
Hubbard & Co., shovels,	151,714
Hydraulic Machine Co., machines,	100,000
Carbon Steel Co., steel,	400,000
Wm. Clark's Sons & Co., iron,	1,000,000
Iron City Tool Works, tools,	158,136
McCullough, Dalzell & Co., crucibles,	200,000
Pittsburgh Malleable Iron Co., iron,	154,869
Pittsburgh Bridge Works, iron bridges,	271,660
Keystone Rolling Mill Co., iron and steel,	848,550
Linden Steel Co., steel,	698,816
Moorhead, McLean Co., iron and steel,	914,507
A. French, Spring Co., springs,	1,180,000
Westinghouse Machine Co., machinists,	450,000
McConway, Torley & Co., iron,	1,477,000
Schiffler Bridge Co., bridges,	500,000

Iron and steel industries of Pittsburgh.

Seaman, Sleeth & Black, rolls,	$435,000
Marshall Foundry Co., founders,	521,593
R. Munroe & Son, boilers,	250,000
L. M. Morris, foundry,	216,068
Park Bro., & Co., steel,	2,048,546
Pittsburgh Steel Casting Co., steel,	204,072
Scaife Foundry and Machine Co., foundry,	114,738
Totten, Hogg & Co., foundry,	158,300
Oliver & Roberts Wire Co., wire,	1,800,000
Oliver Iron and Steel Co., iron and steel,	2,000,000
Koehler & Strong, scrap,	165,000
Morris & Bailey, steel,	138,000
Phillips, Nimick & Co., iron,	708,975
M. Lanz & Son, nuts, bolts and bricks,	125,000
Lewis Foundry and Machine Co.,	271,677
The Klein Logan Co., tools,	100,000
C. J. Reiling, iron railings,	100,000
Marland, Neely & Co., nuts and bolts,	108,698
Phillips Mining Supply Co.,	100,000
Republic Iron Works,	600,000
Union Foundry and Machine Co.,	150,000

A large business for one city.

Making a total of $59,115,709. But merchants' sales are no doubt included in the list, and so the statement is not to be taken as showing the exact amount of the city's production of iron and steel. Yet after due allowance is made for the business of mercantile houses, the aggregate value of the industries must be a very large sum for one city—probably more than double the value of all the iron and steel products of Ontario establishments in the census year 1880.

GREAT BRITAIN AND THE UNITED STATES.

Growth of pig iron production in the two countries.

The growth of the iron industries of the United States furnishes striking evidence of the progress made by that country during the last quarter of a century, and Great Britain, so long the leader of the world in the production and manufacture of iron and steel, is now reduced to second place. The following table shows how the pace has been kept up by both countries in production of pig iron for a period of twenty years, quantities being expressed in gross tons :[3]

Production of pig iron in Great Britain and the United States during twenty years.

Years.	Great Britain.	United States.	Years.	Great Britain.	United States.
1872	6,741,929	2,548,713	1882	8,586,680	4,623,323
1873	6,566,451	2,560,963	1883	8,529,300	4,595,510
1874	5,991,408	2,401,262	1884	7,811,727	4,097,868
1875	6,365,462	2,023,733	1885	7,415,469	4,044,526
1876	6,555,997	1,868,961	1886	7,009,754	5,683,329
1877	6,608,664	2,066,594	1887	7,559,518	6,417,148
1878	6,381,051	2,301,215	1888	7,998,969	6,489,738
1879	5,995,337	2,741,853	1889	8,322,824	7,603,642
1880	7,749,233	3,835,191	1890	7,904,214	9,202,703
1881	8,144,449	4,144,254	1891	7,406,064	8,279,870

THE INDUSTRY IN GREAT BRITAIN.

An arrest of expansion.

In 1892 the make of pig iron in Great Britain was 6,616,890 tons and in the United States 9,157,000 tons, and it appears likely that the latter country will maintain the supremacy, although it looks as if production would decline 1,000,000 tons this year. In both countries there has been an arrest of expansion, which of course could not long continue at the rate of the last twenty years; and cautious men may be led to consider whether there is room in the world for many more rival enterprises. The situation in Great Britain

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[3] Mineral resources of the United States, 1891, p. 52.

ed regarded as serious, and the following extract from the address of
indsor Richards, president of the Iron and Steel Institute, at the May
g of that body in London, may be accepted as a trustworthy presenta-
it :

Richards.

he present meeting is held under circumstances of great depression and
for the iron and steel trades. The year 1892 was, in many respects,
the very worst those industries have ever known. The production of
on fell off to the extent of over 600,000 tons. The production of
ht iron and steel was also much under that of some previous years.
ost serious falling off however was in the production of steel rails. The
of rails in 1892 was not much more than one-half that of 1890, while
ports of 1890 were much under those of some previous years. The
alling away in our exports of metal and machinery in 1892 as compared
891 amounted to over seven millions sterling. One characteristic of
on industry of the past year has been the great falling off in the quantity
iron made from English ores. The imports from Spain during 1892
ted to 3¾ millions of tons, equal to a production of 1,800,000 tons of
on. The total quantity of pig iron made in this country in that year
,616,890 tons, so that 26 per cent. of the whole production was made
mported ores.

A period of depression and gloom.

Imports of ores from Spain.

It is remarkable how all the principal iron making districts have of late
increased their consumption of imported ores and reduced the use of
ores. In Scotland the make of well-known brands of Scotch foundry
as been largely reduced from year to year, until now more than 24
nt. of the production is obtained from foreign ores. South Wales has
cally ceased raising iron-stone and depends almost entirely on foreign
es. Cleveland has immense quantities of phosphoric iron-stone at its
cheaply won, but 20 per cent. of its total make of pig iron comes from
arried more than a thousand miles. Even Lancashire and Cumberland,
hematite ores of the highest quality close at hand, have of late years
ded their use of Spanish ores. Is it possible for the north of Spain,
in 1892 supplied us with 3¼ millions of tons of ore, to maintain that
t for a much longer time? It is generally thought that the most valu-
nd extensive deposits are being rapidly exhausted, and that some of the
productive mines are not likely to last more than a few years longer.
month I visited Bilbao and made careful enquiries from competent
rities on the spot, and learned that, with the exception of the large mines
l by the Orconera and Franco-Belge companies, there are no very exten-
nines left to be worked. Indeed were it not for the recent successful
ation of the spathic ores which underlie the Rubio ore, the duration of
strict at the present rate of output—4 million tons per annum—would
been within measurable distance; but there are very large deposits of
ic ore, the depth and extent being as yet unproved. Calcining opera-
in the near future will be largely carried on, making the spathic ore
in the raw state contains 43 per cent. of iron, and 25 per cent. carbonic
give in the calcined condition 58 per cent. of iron, thus making a very
ble mineral, having only 2 per cent. of moisture as received. Calcining
are already erected, one large kiln economically and effectually calcining
tons of raw ore weekly. It seems probable that this successful dealing
the spathic deposit will extend the life of the district fully ten years.
ust be understood however that this length of life does not apply to the
nera and Franco-Belge properties.

Decrease in consumption of home ores.

Exhausting the Spanish deposits.

There are large deposits of ores free from phosphorus in the neighborhood
ville and in the south of Spain that will become available, but consider-
sums of English money will have to be expended in opening out the
s and conveying the mineral to the ship; but in the words of Mr. Gill
e Orconera Company, who has seen all the recently discovered large

Richards.

deposits, there is as yet only one Bilbao. Under these circumstances it is natural that our attention should be arrested by the enquiry, whether, if the Spanish supplies were to be suddenly cut off, we could depend wholly on our home mines. The west coast has raised 2¾ millions of tons of ore free from phosphorus, and could most probably increase that quantity to produce 1½ millions of tons of pig iron should the demand arise.

Utilizing the phosphoric ores.

"During the twelve months ending December, 1892, the quantity of basic steel made in England was 406,839 tons, of which 108,056 tons were open-hearth steel. In Germany and Luxemburg 2,013,484 tons of steel were made from phosphoric ores, of which quantity 186,252 tons were open-hearth, the balance being basic Bessemer steel.

Value of the Basic process to the British mine owners and iron makers.

"Very much more prejudice has existed in England than on the part of continental buyers against the use of steel made by the basic process. This seems only natural when no difficulty existed here in procuring ores free from phosphorus, and in the event of foreign supplies being cut off such prejudice would doubtless quickly disappear. There need therefore be no apprehension of our being able to supply all the iron and steel we may be called upon to produce. Indeed the great trouble seems to be that of being able to procure sufficient work to keep our large establishments employed. We could quickly make ourselves independent of foreign supplies of ores, except in the manufacture of high percentages of manganese in spiegeleisen and ferro-manganese, and in this respect we are entirely dependent on foreign countries, the English spathic ores not being rich enough to give above 10 per cent. manganese in spiegel."

And in the close of his address Mr. Richards said :

Advantages of better organization and improved mechanical arrangements.

"All those who manage steel works either for the production of rails or ship plates, pride themselves on their power of organization, not only to increase output, but to maintain high quality. Then again the ingenuity of our engineers has been called into play to substitute mechanical arrangements for the so-called cheap labor. One cannot fail to observe how few men are employed in a mill turning out 5,000 tons of finished rails weekly. The heavy ingots are conveyed by small locomotives to the rolling mills, are moved to and from the several grooves of the rolls by live rollers, are turned over and carried sideways, rails are rolled in 155 feet lengths, are carried to the saws, are cut, are conveyed away, are placed on hot banks to cool, all by ingenious mechanical contrivances; the same may be said of plate rolling. It is only when the material becomes cold that labor becomes expensive and troublesome; but the more difficult it becomes the surer will machinery be devised to dispense with it.

But there is another side.

"So successful have we all been in economically increasing production that we have inundated and swamped the markets for the time being; at present and for some time past there is not enough work for half the steel-producing power of the country. Thus we go on and we look about in vain for new markets. We compare America with 60 millions of people, having 175,000 miles of railway, with India having 250,000,000 of people and only 17,000 miles of railway, and wonder why under our sway it develops at such a wretchedly slow rate. Where is the trade to come from to keep our workmen employed and our establishments in operation? No one seems to be able to answer this question; but we know that we have had many serious depressions before—though none seem so deep, so prolonged as this. The iron and steel trades may be likened to Pandora's box, from which, once filled with all good things and all bad, everything escaped, the good things back to heaven, and the evils to infest and plague the earth; but there is still left to us that which never deserts us, the inestimable blessing—Hope."

And what are the lessons of the situation for us? Not simply to fold our hands, nor to push a business beyond the limits of our requirements. But rather to undertake that which is nearest us, what we most need, and what we can engage in with the best assurance that the effort will not be lost.

VI.

LOCATIONS FOR PIG IRON PRODUCTION.[1]

By John Birkinbine, ex-President American Institute of Mining Engineers.

The advances which brought the United States to first position as a producer of iron ores, pig iron, Bessemer steel and other products naturally drew attention to the importance of developing mineral resources lying dormant, and of establishing industries for the production and manufacture of iron and steel in new locations. To secure this, various methods for encouraging capital to embark in new enterprises have been employed, and the erection of blast furnaces for the production of pig iron has attracted first attention. If the statements of advantage claimed for certain locations as set forth in newspaper articles, or by special announcements in circulars, were all true, the United States would be unusually favored both by the number and the generous distribution of sites which are peculiarly adapted for the production of pig iron, and sections of the country now sparsely populated should develop rapidly into series of adjoining commercial metropoli.

Influence of improved processes in developing mineral resources.

This country of great resources has before it great possibilities, and the liberal distribution of deposits of mineral undoubtedly offer numerous available sites for the establishment of iron-producing or iron-manufacturing plants, while an augmenting population will seek new industrial centres; but the available locations for successful iron manufactures or for future cities are by no means as numerous as the published statements referred to indicate. It is not necessary to assume that all or most of such statements were made without a basis, for in a large number of instances, and possibly in most of them, there have been apparent reasons leading to the assumption that peculiar advantages are possessed by special locations.

ADVANTAGES OF LOCATION.

Iron ores, fuel or flux, or all three, may occur within convenient distance of a site for a projected blast furnace, and such site may have the added advantages of ample labor at satisfactory prices, good transportation facilities, etc., yet the construction of a blast furnace for the production of pig iron may be followed by financial disaster. The quality of the ore, coal and limestone, the quantities which can be advantageously assembled at the point for producing the metal, the method of winning these raw materials from the ground, and the cost of mining and preparing them for the furnace must enter into any estimate in which the advantages of erecting a new smelting works are considered in comparison with those existing elsewhere.

Conditions of good location for a blast furnace.

A most important consideration is a convenient market for the product, for although improvement in railway construction and operation and competition between different lines of traffic have so reduced the transportation charges that localities hundreds of miles apart are now as close competitors as were those in former years which were separated by but a few miles, the advantage of consumption close at hand is by no means a small factor in determining the financial success or failure of an iron-producing enterprise.

A convenient market for pig iron.

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[1] Reproduced from the Engineering Magazine for March, 1893, with the kind permission of the writer and publishers. Mr. Birkinbine is one of the first authorities in the United States on the subject of the iron industry.

Town-booming schemes to be avoided.

Of the numerous schemes in which blast furnaces have been used as foundations upon which to start real estate speculation or town "booms," some have had little if any substantial basis; others have possessed one or more of the factors which are essential for the economic production of pig metal, and some which have been started and progressed well on towards completion, have already demonstrated the error of attempting to produce pig iron, or of using a blast furnace as the initiative industrial feature for the establishment of manufacturing centres where other conditions do not demand such centres.

The employés about a blast furnace are not as a rule the best calculated to form nuclei of large populations. Outside of such as are paid salaries, few receive compensation above that given to ordinary labor (except for the extra hours per day which they work), and the labor about blast furnaces cannot be considered as fixed or permanent. Recognizing this, some of the promoters of town ventures secured the promise or the actual establishment of industries which would use a larger number of skilled employés, and generally such as obtained better wages than the blast furnaces offer. Some of these advanced industries rely upon the product of blast furnaces for their raw material, while others may be entirely independent of the furnaces. The industrial plants proposed or erected may either embody new equipments or those moved from other sites and renewed in appointment so as to be creditable to any locality; but in other cases investments have been encouraged by the bodily removal to new sites of plants which have outlived their usefulness in their old locations, largely on account of antiquated equipment to which little or no addition was made for the changed conditions. Disaster may be expected to follow enterprises established at locations which do not, as far as practicable, possess advantages equal or superior to others which have been in operation elsewhere for a term of years.

A new industry, or the opening up of a new industrial district, must meet competition, and break into established trade held by older concerns, a fact which often seems to be lost sight of by those who press the claims of some locations. Under ordinary conditions a new business venture is sufficiently handicapped in securing an entrance into active trade, and needs all the advantage which good equipment, substantial construction, economical management and good financiering bring to assist it in competing for a share of business.

If a blast furnace were necessarily the best starting point for an industrial town or city, the number of such settlements in the older iron-producing districts would be greater than they are, but any one conversant with the location of existing blast furnaces recognizes how many of these, although they have occupied the same location for a number of years, and may have been well managed and operated with skill, have gathered scarcely more than a hamlet about them. On the other hand, a number of instances could be quoted where towns and cities have developed from a single forge or blast furnace, which was erected in such location as to have the advantage of good and cheap raw materials and an ample market; in fact some new important settlements originated from the location of plants which did not possess all of the advantages named. But the exception proves the rule, that the future advance in real estate or the prospective establishment of towns or cities should seldom have a prominent place in estimates when a location is to be chosen for the production of pig iron. The prime considerations should rather be the quantity, quality and cost at which raw materials and labor can be assembled, the character of pig iron which can be made, and the market offered for its sale.

The prime considerations of suitable locality.

THE LESSONS OF EXPERIENCE.

Elements of success and failure.

An examination of the development of the pig iron industry of the United States demonstrates the extent to which success has been and will continue to be affected by location, and a retrospect of the history of existing and apparently prosperous furnaces shows how many have met with financial difficulties, necessitating change of ownership or of management, while today close attention and economy are essential for their continued activity.

Quality, quantity and cost of raw material.

If abundance of raw material is required there would be no necessity for the number of idle iron ore mines which today are scattered through some of the older iron-producing districts, convenient to fuel supplies; but the quality and the cost of winning the ore, as well as the quantity, must be considered. The material won from some of these idle mines was of a very satisfactory character for the production of metal in demand, until changed conditions of trade required ore of different composition; although some of the mines which are inactive produce ore of a quality equal or superior to that largely used in other sections of the country where the deposits are newer or can be worked more cheaply. Other mines have been wrought until the extraction of the ore renders insufficient profit to permit competition with richer ores brought from long distances.

Cheapness and supply of raw materials not alone sufficient.

If the abundance of satisfactory fuel obtained close to the plants were the chief necessity for economical operation of blast furnaces, and if this could not be off-set by other advantages there would be no excuse for the magnificent iron and steel industry centered at Chicago; for there the blast furnaces have no raw materials near at hand, except the limestone, and the per diem rates of labor average higher than in some other sections of the country where pig iron is made. On the other hand, if an abundant supply of iron ore off-set the advantage of near fuel and a good market, the enormous output of the blast furnaces in the vicinity of Pittsburgh would seem to be produced at a decided disadvantage, for with the exception of the local mill cinder and a partial dependence of some outlying furnaces upon local carbonates and brown hematites, all of the iron made in Pittsburgh and vicinity, in the Shenango valley of Pennsylvania and the Mahoning valley of Ohio, as well as that produced about Wheeling, West Virginia, and Johnstown, Pennsylvania, is obtained by smelting iron ores brought from lake Superior.

Decline of number of furnaces, and increase of production.

The surroundings which several decades ago made a location advantageous for the smelting of iron ores may have less weight in determining the erection of a blast furnace plant at the present time, several causes combining to affect the influences which certain conditions exert. Owing to the increased production of blast furnaces now constructed, due to the average size, the general use of richer ore mixtures, and the more intelligent management which is bestowed upon the operation of the existing plants, the number of blast furnaces in the United States, either active or likely to be in operation, has declined since 1881, when 717 were recorded. In 1890—the year of our greatest pig iron output—but 562 furnaces were on the active list; of these but 311 were in operation at the close of 1890, being a smaller number than in any of the preceding twelve years with but three exceptions (1883, 1884, 1885), in each of which the pig iron output was less than half of what it was in 1890. The production of pig iron in the years 1891 and 1892 did not reach that of 1890, but owing to some new plants having been completed or blown in the number of furnaces was slightly increased. The record shows that in 1890 there were 562 furnaces on the active list, with an output of 9,202,703 gross tons; in 1891 the furnaces numbered 569, and the output was 8,279,870 gross tons; and in 1892, 564 furnaces were reported, all of which however were not in operation, the tonnage for the year being 9,157,000 gross tons.

Economy of centralizing the industry and increasing the capacity of furnaces.

Therefore an increased output of pig iron is secured from a decreased number of blast furnaces; and as there is a growing tendency to centralize industries (groups of furnaces under one management becoming more common) there must necessarily be fewer specially available locations at the present time than formerly.

A quarter of a century ago a blast furnace which averaged from thirty to thirty-five gross tons of pig iron daily was recognized as of large size and doing excellent work. Now, a production exceeding two hundred tons per day by blast furnaces is not considered remarkable, and where a number of large structures are combined under one management they present a problem for assembling raw materials vastly different from that of the average furnace twenty-five years ago.

Large plants demand large basis for supplies.

With the perfection of mining appliances, the intelligent management of mines, the facilities for winning or transporting ores, fuel and flux, there may be really less personal supervision necessary in assembling the raw materials for one of the large plants than was demanded of the managers of the smaller ones, who had to rehandle the material and furnish at least a part of the transportation. But for the larger plants the basis of supply must necessarily be larger. Increased tonnage of ore, fuel and flux demands greater available supplies, and hence dependence upon merely local deposits of iron ore is now uncommon. Advances in the technology of blast furnace operation and the increasing demand for metal of special chemical compositions also affect the reliance which may be placed upon local deposits of iron ores, for blast furnace managers must work within narrow limits as to the character of pig iron made. Hence the location selected for plants should be accessible to supplies of ores from which such mixtures can be made as will permit of producing not only the grade but the quality of metal required, at prices which admit of manufacturing it advantageously so as to meet the available market.

INFLUENCE OF THE BESSEMER PROCESS.

Development of the lake Superior iron regions.

The development of the lake Superior region, which up to the close of 1892 contributed more than 74,000,000 gross tons of iron ore, is not alone due to the high percentage of iron representing the average of the ore produced, for the variety and composition of the ores which have been mined, and which fit them for different purposes, have had a marked influence in this development. In view of the generally-accepted belief in the prime necessity of ores of Bessemer grade, it may sound peculiar to assert that had all of the iron ores won from the lake Superior district been sufficiently low in phosphorus to be acceptable for the production of pig iron for the Bessemer process, the development of this district would have been less rapid than it has been as a producer of the various grades of iron ore.

Increase in make of Bessemer iron and steel.

To emphasize this fact it is unnecessary to go further back in history than a few years, for if an interval of five years ending December 31, 1891, be taken and the proportionate amounts of Bessemer and other kinds of pig iron produced are tabulated, such statement shows that in the year 1887, 44.81 per cent. of the total pig iron output of the country was of the Bessemer quality. In 1888 this percentage was reduced to 40.65 per cent., the total output of pig iron being practically the same as in 1887. In 1889 there was an increase of more than 1,000,000 gross tons in the annual production of the country, and in that year the quantity of Bessemer pig iron made was 41.45 per cent. of the total. Another increase of more than 1,500,000 tons brought the pig iron made in the United States in 1890 to a total of 9,202,703 gross tons, of which 44.47 per cent. was of Bessemer quality. The year 1891 showed a decline from the production of 1890 of nearly 1,000,000 tons, and in that year 41.94 per cent. of the total was of Bessemer grade. The figures which have just been compiled for the year 1892 indicate that out of the total production of pig iron, 9,157,000 gross tons, 48.53 per cent. was of Bessemer quality.

Effect upon location of furnaces.

The growth of the Bessemer steel manufacture in this country has been phenomenal, continuously increasing in twenty-five years from a product of 3,000 tons to one of more than 14,000 000 gross tons, such an industry necessarily exerting a very marked influence upon the location of the furnaces which supply the metal for it, and upon the development of iron ores which are used in these furnaces. It is probable that the majority of persons suppose the great steel works at Chicago, Pittsburgh, Baltimore, Harrisburg, Johnstown, Scranton, Bethelem, Troy, etc., to have been located on account of blast furnaces connected with them. It is undoubtedly true that some of these plants owe their existence to an original forge or blast furnace, but an investigation will show that, properly speaking, the existing blast furnaces were located at these points because of the steel works, and are established so as to supply to large industrial plants the raw material upon which they must depend.

Influence of Foundry and Rolling-mill Trade.

Convenience to market affects location of furnaces producing foundry and mill pig.

In a similar manner it may be shown that most of the blast furnaces which are producing pig iron of grades particularly adapted for the foundry or rolling-mill trade owe their situation more to convenience to a market for the product, than to being specially near to supplies of fuel or of ore peculiarly suited for the product made. Taking the five years 1887, 1888, 1889, 1890 and 1891, the figures show that, while the blast furnaces located in the vicinity of Pittsburgh and in western Pennsylvania and eastern Ohio increased their total output of pig iron nearly 50 per cent., much of this growth was in the production of Bessemer pig iron, the annual output of which augmented nearly 80 per cent. But on the other hand, while the state of Illinois increased its total production of pig iron one-third, its output of Bessemer was augmented but one-tenth in the five years named: that is, in spite of the state of Alabama trebling its output of foundry and mill pig iron in five years, and other southern states adding to the volume of this class of metal, the state of Illinois, with its large steel industry, accessible to liberal supplies of iron ore suitable for producing Bessemer pig iron, increased the quantity of ordinary pig metal produced three times as rapidly as that used for Bessemer purposes. The advance figures of pig iron production for the year 1892, just published, show a decided increase in the quantity of Bessemer pig iron made, the tonnage and the proportion of this metal being greater than in any other year. At present writing the relative amounts for specific districts cannot be given exactly, but a comparison of the records of the years 1887 and 1892 indicate the following: In the Pittsburgh district the output of Bessemer pig iron was more than double, while the total of all kinds of pig metal increased less than 80 per cent., showing a gain in Bessemer pig iron at the expense of mill and foundry iron. Similarly the greater portion of the advance in Illinois last year was in Bessemer pig iron, the increase in six years being 88 per cent. in the production of total pig iron, and 63 per cent. in that of Bessemer pig iron. Alabama's product, none of which was Bessemer pig iron, was two and one-half times greater in 1892 than in 1887.

General Conclusions.

Quantity, quality and market cost are the essenc of suitable location.

The influence of location upon the pig iron industry would seem therefore to be based not only upon the possibility of assembling the raw materials, but also upon the opportunities for marketing the product advantageously. A blast furnace may act temporarily as a sign board for a real estate "boom," although its operation may be at a financial loss, but ultimately dividends or profit must come from it, or failure will be written against it. A smelting plant may instil life into a district, and cause the exploitation of old or the development of new iron ore mines; but unless the ore supply is ample, its quality such as is in demand, and the winning of the ore at low cost can be carried on for a term of years, the success of the enterprise is problematical.

The continued existence and evidences of prosperity of some of the plants located in sections of the country where the use of local ores is practically abandoned, and the late reconstruction of some of these plants to depend upon ores brought from distant points, indicate the importance of convenience to market and an established trade. The enormous output of iron ore from the lake Superior district, which is conveyed by rail from the mines to extensive shipping docks, loaded on vessels which carry it to equally extensive receiving docks, and again transported on cars for points of consumption from 300 to 1,000 miles from the mines, demonstrates the growing appreciation of high-grade ores.

A tendency to centralization.

The extensive plants distant from ores or fuel, or both, which have been established near important commercial centres, and the concentration of allied industries at these points, evidence the general tendency of iron production to become centralized in a comparatively small number of locations.

As the rapid increase of the population of the country changes the requirements of different sections, and consumers of iron and its manufactures multiply rapidly, deposits of ore yet unexploited await the local demand for metal which will bring these ores and fuel for smelting them together. It is probable that some future industries will occupy territory which years ago or quite lately was developed in part by ventures which failed because they were in advance of the necessities of the times; the fact that some of these earlier attempts proved disastrous may act as a check on improvements in sections which would sustain a considerable and increasing industry.

Premature enterprise.

Deception as to the quantity of manufactured material required in certain districts has cost enthusiastic projectors much loss, and in some cases has condemned by premature efforts enterprises which would prove successful later. The apparent quantities of iron used often offers inducement to believe that a large local market exists, but these quantities when analyzed show that such varieties of metal must be made, and that so many minor industries must be established to transform the crude material into the merchantable shapes demanded, that years elapse before new blast furnace plants overcome the difficulties which await them.

Influence of progress in the metallurgy of iron.

The requirements of the steel works for iron of special composition has been followed by foundries and mills making more rigid specifications; and this in turn has influenced the ores in demand by blast furnaces. Progress in iron metallurgy has shown where economies can be introduced which reduce the fuel and labor per ton of iron made, and an appreciation of the relative values of different percentages of iron in ores has increased the demand for those which may be classed as rich in iron. Each year shows an increase in the average percentage of iron in the ore mixtures used in American blast furnaces and longer distances covered by the rich ores in reaching points of consumption. It is probable that future advances may be in the direction of conveying fuel to meet these ores, particularly if the meeting points furnish good market facilities for the product, and that the use of lean ores will be chiefly in connection with great local advantages as to the other features which go to make up successful blast furnace enterprises.

VII.

NICKEL AND COPPER.

Ores of nickel and copper in the Sudbury district.

The Sudbury district continues to be searched for copper and nickel, and discoveries of the ores of these metals continue to be made in various localities. The area is now shown to be of large extent; but the limits of it are not defined; neither is it certain that every body of ore even in territory most familiar to prospectors has yet been discovered. The close growth of small timber on tracts swept over by forest fires twenty or twenty-five years ago hide out-croppings of ore, or the familiar surface signs by which its presence is indicated, from any but the most careful examination, while the alternation of rocky range and swamp land greatly increase the difficulty of traversing the country. It is not unlikely therefore that the diligent prospector will be rewarded by new and perhaps important discoveries of ore for some time to come at points convenient to existing railway lines, and that it will be many years before the whole of the nickel and copper-bearing formations are delimited on the maps of the country. But what is already known of the extent of the ore bodies, both by deep workings in the mines and the test pits of exploring parties, leaves no doubt in the minds of practical men who have examined the district that nickel and copper are there in illimitable amount; and the strong probability is that a hundred years hence the supply will appear to be as inexhaustible as it is to the miners and explorers of to-day. It is likely too that other parts of the Province besides the Sudbury district will be found to yield both nickel and copper. The Huronian belt in which the known deposits lie extends from the north shore of lake Huron across the Province to the Quebec boundary at Abbitibbi lake, a distance of 300 miles, the breadth of which is about 75 miles,—but embracing some Laurentian areas. On the shore of lake Huron copper and nickel were discovered in this belt nearly fifty years ago, and far to the northeastward of Sudbury prospectors report that they have observed indications of the same ores. Of course the character of the Huronian rocks is not uniform over a wide extent, and great local differences may be looked for in an area of 22,000 square miles; but it is certain that all the chalcopyrite and nickeliferous pyrrhotite of this great Huronian belt are not confined to one or two townships in the vicinity of Sudbury. During the past year too a discovery is reported on Lake-of-the-Woods which may be only the beginning of valuable finds there. At any rate further prospecting in that region ought to be encouraged by the history of exploration in the Sudbury district. Interest has also been recently revived in the Bruce Mines locality, and possibly the old workings there which were carried on with so much spirit for thirty years—beginning with 1846 and ending with 1876—may once again become the scene of an active industry. It is by no means certain that those mines could not be made to pay under modern methods of working and with the facilities for transportation which are now provided.

Extent of the Huronian belt in which the ores are found.

Discovery on Lake-of-the-Woods.

Bruce Mines.

COPPER ON POINT MAMAINSE.

Copper ore and native copper on Point Mamainse.

A locality of bright promise is Point Mamainse on the east coast of lake Superior, where development work has been undertaken during the past year, and to which reference is made in the Report of the Inspector of Mines, who visited the place last summer. The following interesting account of this property and the nature of the work undertaken upon it was furnished me last November by H. S. Sibley of Detroit, in the course of an interview:

Sibley.

"I am one of two trustees holding for a syndicate the Mamainse copper locations on the east coast of lake Superior. They consist of 11,200 acres, Sibley.

Extent of the locations.

which were purchased from the Crown by the Montreal Mining Company in 1856. A little prospecting was done by Joshua Coatsworth about 1858, and afterwards by the Ontario Mineral Lands Company in the winter of 1881-2. Two small exploring shafts were sunk in the conglomerate on the Pancake location. This bed is 9 to 14 feet thick and carries one to two per cent. of native copper. No further work was attempted until the autumn of 1891, when a party with Captain T. H. Trethewey in charge was sent up to explore with a diamond drill outfit. Drilling was carried on upon five veins to the extent of 3,643 feet, and to 357 feet on a conglomerate bed; the cores showed native copper to depths of 40 to 320 feet in the veins. The veins vary in width from 3 to 12 feet, and consist of calcspar and fragments of wall rock (conglomerate and trap) cemented by native copper. Jasper pebbles are also found in the veins. In 1892 drilling was continued until July, but in June work was commenced on an exploring shaft 7 by 9 feet, which was carried down upon one of the veins to a depth of 32 feet. A stream runs along the course of this vein, crossing and re-crossing it at intervals, so that some difficulty was experienced in keeping the shaft free from water with the methods at control. The ore was found to be rich throughout the whole depth of the shaft, and so satisfactory was it that the men were set at work to strip the vein and make open cuts upon it at various points for a distance of 1,600 feet; the width varies from 3 to 6 feet. The course of this vein is a little west of north and lies between amygdaloid trap on the west side for foot wall and conglomerate on the east side for hanging wall, showing a lateral thrust of 90 feet About five tons of ore was taken out of the shaft, from which fair samples were selected and sent to the St. Louis sampling and testing works in August. Following is the report made to me by the manager of these works:

Exploring with diamond drill.

Sinking an exploration shaft.

'St. Louis, Mo., September 20, 1892.

'H. S. Sibley, Esq., 80 Griswold street, Detroit.

Analysis of the ore

'Dear Sir,—We have just wired you results of tests of the two lots of copper ore sent us, and we herewith present more fully the details of these tests. The larger sample lot, weighing 1,196 lb. net, was crushed in jaw crusher and run through our 3-stamp battery to separate the rock material and finer copper from the coarse metallic copper. The former as tailings were carefully saved in settling tanks, weighed and sampled and assayed for copper and silver. The coarser metallic copper was carefully sampled down three times to secure three separate samples in order to secure a better check on a difficult material to sample. These three samples were assayed for copper and silver separately and the average taken. As a result of all these operations we find the lot to contain 22.78 per cent. metallic copper and a trace of silver. The other sample lot marked gray ore was crushed in a jaw crusher and rolls until it was fine enough to quarter down to sample. An assay for copper and silver gave the following results: Copper, 18.84 per cent.; silver, 1.8 oz. per ton. We regret that owing to the great difficulty in handling such obstinate material we have not been able to give you results sooner, but trust they will be in time to serve your purpose. Yours truly,

showing a high percentage of copper.

'St. Louis Sampling and Testing Works,
'William B. Potter, Manager.'

Sinking the shaft to a depth of 500 feet.

"The gray copper ore is found generally throughout the vein, but chiefly on the foot wall. The native copper ore is generally disseminated from wall to wall. The trustees have given an option on the property to a Detroit syndicate, by whom operations to sink the shaft to a depth of 500 feet will be carried on through the winter. This work it is hoped will be finished in ten months. Air compressor, hoisting engine, boilers, drills and all necessary supplies were delivered at Point Mamainse on the 17th of November."

geological formation at Point Mamainse is the same as that of Keweeoint on the south shore, where are located the great copper mines of gan.

Geological formation.

THE PRODUCTION OF NICKEL.

Output of the Sudbury works.

Markets for the matte.

Refining works in the United States.

The Gap mine closed down.

e quantities of ore mined and smelted in the Sudbury district last year ven on page 8 of this Report. The product of the furnaces, consisting of ry and bessemerized matte, held of metallic nickel 2,082 tons, of copper tons, and of cobalt 8½ tons. These figures of metallic contents are esticomputed from the analyses of sample lots, and are no doubt as accurate h estimates can be made; they are so accepted by sellers and buyers of atte. The whole matte product of the several furnaces is sent out of the y to be refined, some of it to Great Britain, some to France, but the r portion of it to the United States. There is in the latter country an demand owing to the use of nickel as an alloy with steel in the manu e of armor plate for battle ships. In 1891 the quantity of nickel con in Canadian matte smelted in the United States was 2,000,000 pounds, f which went into the general market, but a considerable amount of it e matte purchased by the Navy Department. This latter is worked up tract, the copper being taken out and the nickel and iron being left as in which form it is delivered to the steel works at Bethlehem and stead to furnish the nickel for armor plates.[1] There are at present nelting or refining works in the United States for treating nickel and mattes, viz.: The works of Joseph Wharton at Camden, New Jersey; of the Orford Copper Co. at Constable Hook in the same state; those Emmens Metal Company at Youngwood in Pennsylvania; and those Canadian Copper Co. near Cleveland. Until recently Joseph Wharton monopoly of nickel production in the United States, and his mine at ster Gap in Pennsylvania produced the bulk of the ore treated at his g works. But since the beginning of 1889 Sudbury has been brought mpetition with it, and the result has been the closing at the end of f the Lancaster Gap mine. So that in 1892 the product of the nickel rs will be all from Canada, except occasional small amounts from Mine tte, and from Nevada, Oregon and the mines near Webster, North Caro- The following table gives the total nickel product of the United States sixteen years 1876-91, together with the value of the same and the per pound:

Nickel production of the United States.

Year.	Quantity.	Value.	Value per lb.
	lb.	$	cents.
1876	201,367	523,554	260
1877	188,211	301,138	160
1878	150,890	165,979	110
1879	145,120	162,534	112
1880	233,893	257,282	110
1881	265,668	292,235	110
1882	281,616	309,777	110
1833	58,800	52,920	90
1884	64,550	48,412	75
1885	277,904	179,975	64.4
1886	214,992	127,157	59.14
1887	205,566	133,200	64.75
1888	204,328	127,632	62.46
1889	252,663	151,598	60
1890	223,488	134,092	60
1891	118,498	76,024	64
Totals	3,087,554	3,043,509	98.57

Mineral Resources of the United States, 1891, p. 167.

[2]Ib. p. 167.

A significant comparison.

Fall in prices, and the cause.

The nickel contents of the matte produced at Sudbury furnaces last year therefore are greater than all the nickel produced by United States mines in sixteen years by 1,076,446 pounds. It will be observed also that the price of nickel as computed from values of the United States product has fallen very materially since 1876. This drop is due chiefly to the working of the New Caledonia mines, by which the world's production was largely increased. Canadian nickel has had a less noticeable effect, but no doubt for the reason that price is determined now mainly by the cost of refining. Yet the ruling price in the London market last year was about 42 cents per pound, while in the New York market in the latter part of the year quotations when given ranged from 48 to 52 cents—the protection afforded by the United States tariff of 15 cents per pound serving to keep up the higher rate in that country. But these prices are presumably for commercial nickel, which is not pure fine.

METHODS OF EXTRACTING THE METAL.*

The wet process as described by Prof. Roberts-Austen.

There are numerous methods already patented for treating ores containing nickel, copper and cobalt, but almost all of them follow the wet process. In a subsequent section of this Report details of treatment are given in a paper by Mons. Levat, and here it may be interesting to give a general description of the process from the pen of Prof. Roberts-Austen, of the Royal College of Science, England :

Roasting the ore.

"The wet method for the extraction of nickel and cobalt from a complex regulus or arsenide consist, in the first place, of a roasting operation having for its object the volatilization of the sulphur and arsenic, and it may be antimony, and the conversion of the iron, nickel, cobalt and other metals present into oxides. Ferric oxide formed in this manner at a high temperature is but little soluble in acids, whilst the other oxides may be readily dissolved.

Dissolving oxides with acid.

On treating the roasted material repeatedly with hydrochloric acid or with dilute sulphuric acid, a residue is obtained containing but little or no cobalt or nickel, and consisting mainly of ferric oxide. Some iron will however have passed into solution. Should the solution contain lead, bismuth or copper, these metals may be precipitated by sulphuretted hydrogen ; but it is customary to precipitate the copper at a later stage of the operations. The bismuth too may be precipitated from a hydrochloric acid solution by dilution with water.

Precipitating the iron.

"The next operation consists in the precipitation of the iron. Any ferrous oxide which may have passed into solution is converted into ferric oxide by careful addition of chloride of lime, followed by the addition of lime, which precipitates the iron. Arsenate of iron is at the same time also precipitated if arsenic is present. Should the temperature of the solution exceed 40°c. some nickel and cobalt are precipitated, as also is some copper.

"Instead of an addition of lime as the precipitant, caustic soda or sodium carbonate is occasionally employed to prevent the precipitation of calcium sulphate when working with sulphuric acid solutions. Care must be taken to avoid using an excess of the precipitant, as the precipitation is a fractional one, and as soon as the iron has been precipitated oxides of the other metals present begin to be thrown down.

Precipitation of copper,

cobalt

"The next stage of the process consists in the precipitation of the copper. This is effected by raising the temperature of the solution to 70°c., and then precipitating the copper by the careful addition of either calcium carbonate, milk of lime, or a solution of soda. If an excess of the precipitant is employed, nickel will be thrown down. When a test with potassium ferro-cyanide shows that the whole of the copper has been thrown down, the cobalt is precipitated from the filtered solution by the careful addition of a solution of chloride of lime to the perfectly neutral, hot and not too dilute filtrate. If too much chloride of lime is added the precipitate becomes nickeliferous, and this must be carefully avoided. The nickel is next precipitated, either by calcium car-

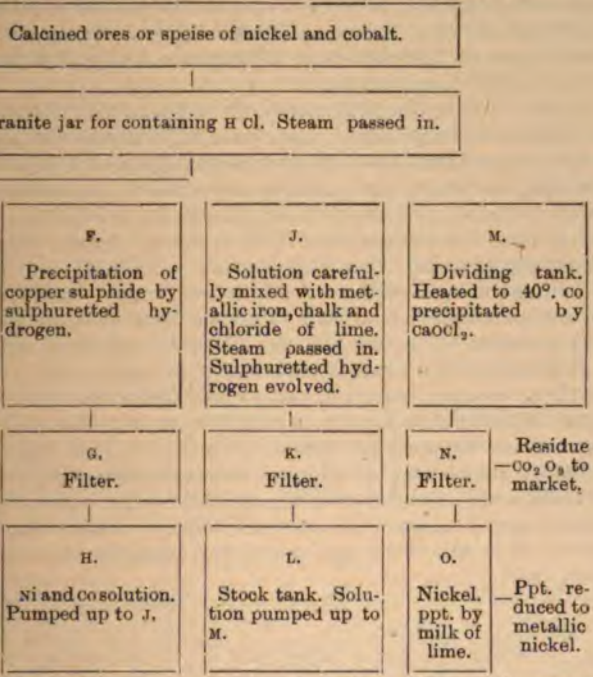
or soda. The nickel hydrate is filtered, dried, heated
e, to decompose any calcium sulphate that may be pre-
idulated water, and finally dried and reduced by carbon-
he metallic state.

and nickel.

ng dependent on the fractional precipitation with the
the several metals present in the ore or metallurgical
ent, is frequently subject to slight alterations of proced-
ng is a description of the process as carried out at a
Kingdom.

A special process described.

ESS FOR EXTRACTING NICKEL AND COBALT.



Calcined ores or speise of nickel and cobalt.

ranite jar for containing HCl. Steam passed in.

F. Precipitation of copper sulphide by sulphuretted hydrogen.

J. Solution carefully mixed with metallic iron, chalk and chloride of lime. Steam passed in. Sulphuretted hydrogen evolved.

M. Dividing tank. Heated to 40°. Co precipitated by $CaOCl_2$.

G. Filter.

K. Filter.

N. Filter. — Residue —Co_2O_3 to market.

H. Ni and Co solution. Pumped up to J.

L. Stock tank. Solution pumped up to M.

O. Nickel. ppt. by milk of lime. — Ppt. reduced to metallic nickel.

Wet process for extracting nickel and cobalt.

fine ore or speise A that has been thoroughly roasted
chloric acid in granite jars, into which steam is passed.
ing for twelve hours. It is allowed to settle and run off
s conducted into the tubs, and when the liquid begins to
r (chloride of lime) is added to peroxidize the iron, and
o boil for about three hours. The arsenic and iron come
o iron be present in the solution some must be added.
n off through filters D, to underground tanks E, whence
F, in which the mass is treated with sulphuretted hydro-
e tanks, of which there are six, there are also three lead
lphuretted hydrogen is produced. In these tanks the
and the nickel and cobalt solution is strained through
nto a second underground tank H. It is then pumped
ere successively mixed with iron, chalk, chloride of lime,
placed above the tank, with a view to precipitate, first,
have passed into solution during filtration, and then the
the place of the copper. The charge is first boiled by
s so as to expel the sulphuretted hydrogen. It is then
r stock. It is next pumped up into a dividing tank M,
ride of lime, the cobalt being precipitated as oxide at a
The solution containing nickel is allowed to run off into

another tank o, in which milk of lime is added, and the nickel precipitated as hydrated oxide. The liquid is allowed to run off as waste. The oxides are pumped into presses, and the water is drained off. The nickel oxide is dried on the roof of a muffle, heated and crushed. It is then mixed with charcoal and heated in a crucible in a reducing furnace for eight or twelve hours. A rough powder is obtained and in this form the metal is sold, or the nickel oxide is mixed into a paste with flour and water, which is heated and cut into cubes. These cubes are placed in crucibles with charcoal and heated to a temperature above the melting power of copper. The nickel oxide is reduced by the charcoal and by the carbonized flour. The metal does not melt, but preserves the form of cubes. The cobalt oxide is removed from the dividing tanks to stone jars and treated by a process similar to that described so as to remove the last trace of nickel. The cobalt is finally sent to the market in the form of oxide."[3]

Price of nickel maintained by cost of refining process.

It will be readily understood from the complexity of this process that it must be an expensive one; hence the high price which fine nickel has maintained. But there are various methods of the wet process, some of which are of recent invention, and possibly the cost of production may be somewhat reduced by them. One of these is soon to be tested at the village of Port Colborne at the head of the Welland canal, where advantage will be taken of the supply of natural gas there for fuel. Gypsum supplied from mines in the adjoining county of Haldimand is to be largely used under this method, and hope is entertained that the sulphuric acid obtained as a bye-product will very considerably reduce the cost of producing the refined metal. The results of this method are awaited with much interest.

A new wet process to be tested at Port Colborne, in which gypsum will be utilized.

Dry processes.

As to dry processes, including reduction of oxide by carbon in furnaces or crucibles and concentration in sulphide or arsenide and subsequent smelting in reverberatory or blast furnaces, there does not yet appear to be absolute certainty that such methods can be successfully and economically applied to the treatment of nickel ores through all stages to the refined metal; but the metallurgy of nickel is so recent a subject of investigation and experiment that no one will be so bold as to say that the last word has been spoken upon it.[4]

PRODUCTION AND PRICE.

Growth of the industry and fall in price of the metal.

Seventeen years ago nickel in the United States was worth $2.60 per pound. Twelve years ago it had fallen to $1.10, the New Caledonia mines having been discovered and opened in the interval. At that time the world's yearly production of nickel was about 1,000 tons. Last year the price fell in the United States to fifty cents per pound, and in Great Britain to 42 cents. But the world's production had then increased to 6,000 tons, of which

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[3] An Introduction to the Study of Metallurgy pp. 268-71.

[4] While this Report is going through the press an interesting correspondence is being carried on upon this subject in the Engineering and Mining Journal of New York, between Robert M. Thompson, President of the Orford Copper Company, and Dr. Stephen H. Emmens, President of the Emmens Metal Company. The following letter from Mr. Thompson is printed in the Journal of June 17th: "In your issue of June 3rd I note a very interesting letter from Professor Emmens headed 'Nickel Winning,' in which he says, 'No wholly dry process hitherto employed is capable of separating cobalt, or even (to a thoroughly satisfactory extent) copper, arsenic and manganese from nickel;' and referring to the Canadian pyrrhotite ores, 'The metal produced by dry methods from such a raw material is not fitted for fine uses.' In reply let me say that the following assays were made by the same chemist for nickel: Wharton's grain nickel, 99.39 per cent.; Martino's disc nickel (finest foreign nickel), 99.06 per cent.: Orford nickel, produced by exclusively dry process from Canadian pyrrhotite ores, 99.23 per cent. As to the quality of the Orford nickel, while I do not claim it is yet as perfect as we hope it soon will be, yet one of the largest consumers of nickel in the country writes me: 'In some respects your nickel is superior to any we have ever used. The metal is very white and remarkably soft and ductile, both of which points are of the greatest value.' Knowing Professor Emmens' interest in the metallurgy of nickel I am sure he will be pleased to see what progress has been made in the dry process for treating this metal." But notwithstanding this assurance, Dr. Emmens does not appear to be wholly satisfied as to the merits of the process.

Ontario produced about one-third and New Caledonia two-thirds. Should increase continue at the same rate for the next ten or twelve years we shall doubtless see great activity in mining, smelting and treating operations in this Province, especially should improvement continue to be made in processes, and prices fall as a consequence. It will not be surprising if in less than ten years prices have fallen to 25, or 20, or even 15 cents per pound, and in that event a large increase may be expected to take place in consumption. Assuming that no larger or better deposits of the ore are discovered elsewhere, what are the prospects of nickel mining in this Province in the event of a growing demand? The answer to this question may be found possibly in the words of the last United States Census Report on Mineral Industries. Referring to nickel and cobalt mining in that country in 1889, the writer says the great feature of the year was "the diversion of all attention in nickel mining to the nickel-bearing copper ores of the Sudbury region in Canada." And he goes on to say: "The course of development showed conclusively that nickel can be produced there for a less cost than anywhere else in the world, so far as the present capacity of the known mines permit of an opinion." And referring to the New Caledonia mines farther on the same writer says: "At present the mines are less influential than those of Canada, for although the ores are fully as rich, labor is not so good, and for imported laborers the climate is bad. The ores are found in v-shaped pockets in serpentine, which is found over two-thirds of the island. Many of the pockets are large, but narrow with the depth. The cost of mining is considerable, and the transportation facilities to the sea coast are poor. It is not probable that the mines can compete successfully with the Canadian."[5]

Prospects of nickel mining in Ontario.

The rivalry of New Caledonia.

Whether the working of manganiferous iron ores on that island containing cobalt and nickel will or will not change the condition in its favor cannot yet be foreseen, but it is hardly probable. Nearness to market, abundance of ore, and a supply of competent free labor and facilities for quick transportation are advantages which the Sudbury district is likely to continue to possess over its New Caledonia rival for all time.

THE FUTURE OF NICKEL.

The future of the nickel industry depends on the distinctive utilities of the metal, on the quantity and cost at which it can be supplied to consumers, and in a less degree on the quality of appearance. Twenty years ago pure nickel was not known in the arts; up to that time it was nothing more than an alloy with other metals combined with it in the ores, from which at best it was only imperfectly separated; and it was not indeed until after the pure metal began to be produced—the first examples of which were shown by Joseph Wharton at the Philadelphia Exposition of 1876—that its most valuable uses began to be found out. Some of these will be mentioned here as evidence of the growth of the nickel trade, and as an indication of the lines upon which it is likely to develop.

Finding out valuable uses of the metal.

The experiments conducted four years ago by James Riley of the Glasgow Steel Works with alloys of nickel and steel made a profound impression when the results were published; and although this may not prove in time to be the most valuable or useful of all the applications of the metal, it is the one which at present most strongly arrests attention in America. The explanation of this fact is found in the tests which, during the last three years, have been carried on by the Navy Department of the United States to determine the sort of material for armor best suited for the battle ships under orders of construction by the Government of that country. Mr. Riley's paper, read at the May meeting of the Iron and Steel Institute in 1889, contained no more than a speculative suggestion of the application of nickel steel to the armor plating of ships, but Secretary Tracy of the United States Navy

Riley's experiments.

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[5] Report on Mineral Industries in the United States at the eleventh Census, 1890, pp. 269-71.

Department regarded the promise held out as "too great to be ignored by a Government requiring 20,000 tons of armor for its new fleet." Accordingly he began a series of trials to prove the suitability of nickel steel for the purpose in view, and not only so but to settle the question of the best armor plate in relation to the best ordnance—the strongest defence to match the most powerful attack. The following extract from the Secretary's report for 1891 shows the progress of the trials up to the close of that year:

Armor plate trials in the United States.

ARMOR PLATE TRIALS IN THE UNITED STATES.

Tracy.

Report of comparative tests in 1891.

"The experiments made last year at Annapolis, described in the annual report for 1890, consisted of a test of the two principal foreign types of armor, the English compound plate and the French all steel plate, and an entirely new plate also made in France upon the special order of the department, of nickel steel. The result of the trial showed that the compound plate was decidedly inferior, and that as between nickel steel and all steel the former had distinct and positive advantages, the all steel plate being broken into four pieces, while the nickel plate remained absolutely uncracked.

Nickel steel plate adopted by the Navy Department.

"A series of tests made during the following spring and summer confirmed the conclusions formed at the Annapolis trial as to the superiority of nickel steel, and the department accordingly decided to adopt it, and made arrangements with the contractors looking to that end.

Trial of home made plate.

"It remained however to give a thorough trial to the first armor of domestic manufacture before beginning to place it upon the vessels, and for this purpose it was decided to order typical plates which should be made the subject of an experimental test. This trial was to ascertain two points: first, whether our domestic manufacturers could produce an armor that would stand competition with the material manufactured abroad; and, second, which of the various modes of treatment suggested would give the best results. In reference to the latter point the questions to be considered were the relative merits of rolling and forging in the manufacture, and the effect of a new method of treatment, named from its inventor the Harvey process, designed to harden the surface of the plate while retaining the toughness of its body.

Relative merits of rolled and forged plate.

"Of the six plates tried three were furnished by the Bethlehem Iron Co., and three by Carnegie, Phipps & Co.

"In these trials, which took place at Indian Head on October 31 and November 14, the plates were subjected to tests more severe than had been applied at any foreign Government trials. Four shots were fired at each plate from a 6-inch gun with an impact velocity of 2,075 feet per second, and an energy of 2,988 foot tons, using the Holtzer projectile of 100 pounds. One shot was then fired at the centre of each plate from an 8 inch gun, with an impact energy of 4,988 foot tons, using Firminy and Carpenter projectiles of 210 and 250 pounds weight respectively. The plates were placed normal to the line of fire.

The results.

"The results of the trial were in the highest degree satisfactory. Each of the six plates manufactured in this country was superior to the English compound plate, while the nickel harveyed plate and the high carbon nickel plate were superior to all the foreign plates of the Annapolis trial. They may therefore be pronounced in advance of the best armor hitherto manufactured in Europe.

Superiority of the nickel plate demonstrated.

"Further light was thrown upon the question of the relative merits of all steel and nickel steel armor, and any doubt which may have remained upon that subject was finally set at rest. Of the three plates made by Bethlehem, two were of nickel steel, one treated by the Harvey process, the other not, and the third was of all steel, harveyed. Both the nickel plates proved to be far superior to the all steel harveyed plate, notwithstanding the advantages which it may have derived from the special treatment; and both proved superior to the French all steel plate tried at Annapolis.

Tracy.

Equality of rolled and forged plates.

“A third nickel plate, manufactured by Carnegie under the rolling process, also showed a marked superiority over the all steel plate of this year, and both it and the corresponding Bethlehem plate manufactured under the hammer showed a capacity of resistance to perforation fully ten per cent. greater than that of the French all steel plate. In this respect the results furnished by the two American plates manufactured by the different processes (forging and rolling) proved to be remarkably uniform, the 6-inch shots that were fired at them differing in penetration but an inappreciable amount.

Lessons of the trial.

“The trial thus definitely establishes the fact that armor of excellent quality may be produced by the rolling process, and that forging by means of the hammer, the greatest source hitherto of expense in manufacture, is no longer to be regarded as an absolute necessity. The importance of this fact can hardly be over-estimated, for it raises a probability that within a year or two the armor-producing capacity of the United States may be quadrupled in case of necessity, and that if we had 10,000 tons to let and could give 18 months from date of contract to commence delivery, the cost of manufacture would be reduced from 25 to 33 per cent., while the work hitherto confined to two firms would be thrown open to a large number of competitors ”[6]

Report of trials in 1892.

In his report for 1892 Secretary Tracy reviews the steps which had been taken by his department for the development of armor, and after special reference to the trials at Indian Head in October and November, 1891, he goes on to say :

Tracy.

Improved methods in the Harvey process.

A comparative failure due to imperfect forging.

“As a result of this trial improved methods were introduced in the Harvey process and further tests were ordered of new plates. The first of these tests took place July 26, 1892, at Indian Head. The plate used was a 10½-inch plate of nickel steel made by the Bethlehem Iron Company, the plate having first been forged to 12½ inches and then harveyed, and finally reforged to its former dimensions. In the two previous trials the corner shots had been fired from the 6-inch gun, and the 8-inch had been used only upon the centre of the plate. In this trial the 8-inch was used for all of the shots. The result was that three of the projectiles were broken up upon the surface of the plate, while the two right hand shells penetrated to a depth of 13 inches. It was evident that there was a want of uniformity in the hardness of the surface and that some special cause must have softened the right hand side of the plate. Upon investigation it became apparent that this was due to the process of reforging, resulting in a lower temperature and consequently reduced carbonization upon this side of the plate. Notwithstanding the penetration of the two right hand shots, the result by which the plate had remained free from cracks after receiving five blows from 8-inch projectiles was an extraordinary confirmation of the expectations that had been formed as to the possibilities of nickel steel treated as described.

A final trial crowns the efforts of four years with highest success.

“It remained for a final trial to demonstrate the wisdom of the steps which had been taken and to crown the efforts of nearly four years with the highest degree of success.

“This trial took place at the proving ground of the Bethlehem Iron Company, July 30, 1892. The plate was of nickel steel, harveyed, of the same thickness (10½ inches) as that of the previous trial, but unlike its predecessor it had been forged to its final thickness before the Harvey process was applied. As in the previous trial the 8 inch gun was alone used. Five Holtzer forged steel shells, weighing 250 pounds each, with a striking velocity of 1,700 feet per second, and each with an energy of 5,000 tons to the square foot, were fired at the plate at a distance of 30 yards.

“Never before these trials had any armor plate in the world been subjected to such a test as was represented by these five blows of a total energy of 25,000-foot tons.

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[6] Report of the Secretary of the Navy for the year 1891, pp. 11-13.

Tracy.

"The result may be told in a word. All five of the projectiles were smashed upon the surface of the plate. The plate showed no signs of injury further than the opening of a slight temper crack four inches in length from one edge, and a wale less than one inch in thickness on the back of the plate opposite each point of impact. The striking ends of the projectiles appear to have been splashed on the face of the plate, filling the slight indentation made by the blow with new material which became welded to the substance of the plate itself and left it as before a flush surface. The remainder of the projectiles could only be found in the shape of innumerable scattered fragments.

The projectiles smashed upon the surface of the plate.

"The result above described has never been equalled or even approached before by anyarmor plate, American or foreign. It has demonstrated that the United States, in the reconstruction of its new navy, which ten years ago had no existence even on paper, is enabled to place upon each and all of its armored vessel a material the like of which the world up to this time has not seen; and that while vast sums have been spent in plating the sides of foreign men-of-war with an inferior material, this country will employ for the purpose an armor which is not only far more efficient, but which represents unquestionably, having reference to the dimensions of plates thus far tested, the highest development of modern science, and a development reached by its own independent efforts."[7]

A result never before equalled or approached.

As early in the course of these trials as September, 1890, the Secretary of the Navy was so well convinced of the superiority of the nickel steel plate that he asked and obtained from Congress an appropriation of $1,000,000 for the purchase of nickel matte. At this time an apprehension existed in the minds of United States authorities that the world might not be able to produce enough nickel for their wants, and they feared that prices would take a bound upward. They accordingly purchased from the Canadian Copper Company 4,536 tons of matte, containing about 900 tons of nickel. "The terms of the contract provided that the material should be delivered on board cars at Sudbury, Ontario, for transportation to such points as might be designated. Deliveries were to begin within three days from the date of the contract, and final deliveries were to be made within one month thereafter. Provision was made by means of competent assayers for ascertaining the quantities of nickel and copper contained in the matte, and that no carload should be shipped in which there was less than an average of 15 per cent. of nickel."[8] The payments to the Canadian Copper Company for matte amounted to $321,321.86, while freight cost $31,134.88, duty on the copper contents $9,547.40, and refining by the Orford Copper Company (in part estimated) $97,582.30, making a total expenditure under the appropriation of $459,586.44. "Of the nickel oxide produced by the Orford Company, by whom the refining is done, we are now using 40 per cent., while 60 per cent. is sold in Europe. Our material, after the payment of all charges, including the price of the matte and of the subsequent reduction, costs us 24 cents a pound, while that of other consumers costs them at least 38 cents."[9] But this is the cost of the oxide. The quantity of armor plate required for an ordinary war vessel such as the United States is constructing is about 3,200 tons, and as the contract with the makers calls for only 3¼ per cent. of nickel in the plate, the quantity of nickel used for one vessel is only about 104 tons, or say 135 tons of nickel oxide. Obviously therefore there is a modest limit to the quantity of nickel required for the manufacture of armor plate for the United States Navy, unless the Government of that peaceful republic should seek to emulate the naval greatness of all the European powers, which is as improbable as that she should follow their example in the creation and maintenance of a standing army.

A large purchase of Ontario nickel.

Nickel required for an ordinary war vessel.

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[7] Report of the Secretary of the Navy for the year 1892, pp. 17-19.

[8] Secretary's Report for 1892, p. 21. The first contract appears to have been for 536 tons, and the second, under date of June 15, 1891, for 4,000 tons.

[9] Secretary's Report for 1892, p. 21.

NICKEL STEEL FOR HEAVY ORDNANCE.

Experiments with nickel steel for great guns.

But there is some likelihood of nickel steel being used in the manufacture of heavy ordnance as well as for armor plate, and at the present time experiments are being conducted to test its suitability for that purpose. The following extract from a lecture delivered before the Franklin Institute of Philadelphia last January by Mr. W. H. Jaques, Ordnance Engineer, will show what is being attempted as well as what has been done in this direction :

Jaques.

"The increasing use of nickel in steel suggests a few words concerning this element, particularly as it is about to make its debut in a large calibre service gun (a thirty-five calibre eight inch B. L. R), the forgings for which have been made by the Bethlehem Iron Company.

Confirmation of Riley's conclusions.

"In this connection it is most seriously to be regretted that circumstances of a discouraging character should have intervened to prevent Mr. Riley's continuing the excellent metallurgical work he so happily and ably commenced in connection with the alloys of nickel and steel, particularly since the publication of his lecture to the Iron and Steel Institute, May 4, 1889, so many of his views have been proved by further experience and practice.

"Bethlehem's part in this work is so well known by the practical results she has obtained, the gun forgings and other products supplied, and the superior resistance of her armor, that I need make no detailed statement here of our accomplishments. Further, they have already been referred to by the chiefs of the Bureaus of Steam Engineering and Ordnance in their last annual reports.

"As you will no doubt recall, Riley, Dick and Packer commenced their experiments with samples of French crucible nickel steel, containing three per cent., five per cent. and twenty-five per cent. of nickel; were subsequently assured by personal investigation that the desired products could be obtained with certainty, not only in the crucible, but with perfect control in the open hearth, and that nearly all the nickel would be found in the steel. Riley, in the lecture referred to, described the action of the steel in the mould, its appearance, value of scrap, and the care and temperatures required to work it. He made a sufficient number of tests to show the marked increase of tensile strength and elastic limit produced by certain increments of nickel without impairing the elongation or contraction of area to any noticeable extent. He pointed out the effects of a variation of the proportions of carbon and manganese with the same percentage of nickel, the point where the increment of nickel changed its hardening influence to one of softening ductilizing, its neutralizing effect upon carbon, the difficulties of machining, and crowned his report by giving due credit to the patentee, French steel makers, his assistants and the authorities.

"Together with other conclusions he said: 'I am glad to be able to state that before the region of extreme difficulty of machining is reached, we have qualities of nickel steel available which will be of the utmost value for a very large number of purposes.'

"Comparing ordinary steel with nickel steel, he adds: 'I think there will be no hesitation in deciding that there will be a very great advantage gained by the use of the latter—advantage either in reduction of scantling or in increased strength and ductility. In the very important matter of corrodibility, it is with the greatest satisfaction I can state that the steels rich in nickel are practicably non-corrodible, and that those poor in nickel are much better than other steels in this respect. Some samples of the richer nickel steels which have been lying exposed to the atmosphere for several weeks will show an untarnished fracture.'

"These experiments to test the non-corrodible qualities of the various percentages of nickel steel, it will be remembered, were made in connection with Abel's corrosive liquid and hydrochloric acid water.

"I have cited Riley's conclusions to show how accurately they have been verified by the results since obtained, which give abundant testimony of the care and faithfulness with which his experiments were made.

"Mr. Hall of Sheffield claims to have made the first nickel steel gun, which instrument is reported to have burst at the first round, the rupture being due to the absence of suitable transverse strength. Whether this was due to the poor steel, poor construction, or the presence of nickel, was not stated.

Krupp's comparative tests.

"Many other nickel steel guns have been experimented with, but Krupp's comparative tests of two three and a half inch field guns, one made of ordinary Krupp steel and the other of nickel steel, appear to be the first trials of much importance that have been given publicity.

"Each gun was loaded with shell containing 170 grammes of picric acid, the centre of the shell in each case being 300 millimetres from the muzzle.

"When the shells were exploded the crucible steel gun burst into many pieces, while the nickel steel gun remained entire, showing an increase of the bore of 7.4 millimetres at the site of the projectile, but no cracks any where.

"The trial was continued with another shell containing 180 grammes of picric acid. Its explosion caused an enlargement of 9.50 millimetres and a longitudinal crack 80 millimetres long. No particle of metal was detached from the gun."[10]

In connection with the foregoing extract from Lieutenant Jaques' lecture the following account from the London Iron of further experiments by Herr Krupp are worthy of notice (unless indeed it is only a different account of the same experiments):

"A new nickel steel, the secret of the manufacture of which has been secured by Herr Krupp of Essen, has been experimented with at Meppen. Two 3.4 inch shells, each containing 6 oz. of picric acid were placed, one in a gun of ordinary Krupp steel, and the other in a gun of the new nickel steel, at a distance of 12 inches from the muzzle. Upon the shells being exploded, the muzzle of the gun of ordinary steel was blown into a number of pieces, but the only effect produced upon the nickel steel gun was a local enlargement of the bore to the extent of a quarter of an inch. In the next experiment a 3.7 inch shell, containing 6.3 oz. of picric acid, was burst in a nickel steel gun at a point 19.5 inches from the bottom of the bore. The results were an enlargement to the extent of one-third of an inch and a fissure of three inches in length. Trials of plates of this nickel steel have also been made and are stated to have given satisfaction."[11]

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[10] Present Development of Heavy Ordnance in the United States, by W. H. Jaques, p.p. 25-27. Lieutenant Jaques (who has served 21 years in the U. S. Navy) is the author of a valuable essay on "The Establishment of Steel Gun Factories in the United States," published in the Proceedings of the United States Naval Institute in 1884 (pp. 527-909). It was largely upon his recommendations that the Government of the United States undertook to promote the manufacture of armor plate and ordnance at home instead of depending for supplies upon European makers, and when the Bethlehem Iron Company six years ago resolved to undertake the manufacture of guns, shafting and armor plates, the position of Ordnance Engineer was offered to Lt. Jaques. The object of the Company was, as stated by Mr. Jaques in an article descriptive of the works published in the Proceedings of the Naval Institute "to erect a plant long needed in the United States to make the country independent in the possession of the means of supplying the nation with the most powerful guns and of equipping her ships with the most efficient shafting and armor." To this end a number of new and large buildings have been erected on the Company's grounds along the Lehigh river, which have been furnished with the best of modern machinery, and new buildings are still going up which, when completed, will no doubt make the Bethlehem works the largest in America. Upon a visit to Bethlehem last October I was shown through the various departments by Mr. Jaques, and a note of the armor plate and ordnance branch of the works may be fittingly made here. Four Siemens open-hearth furnaces are employed in the production of nickel steel, two of which have a capacity of 40 tons each per day of twelve hours, one of 20 tons and one of 10 tons. The process of alloying the metals is claimed to be a company secret, and to give better results than is obtained elsewhere. During my visit the 20-ton and one of the 40-ton furnaces were tapped and run into a mould, casting an ingot of 60 tons nickel steel. This contained 3¼ per cent. nickel, which is the Government requirement for armor plate, or a total of very nearly two tons (1.95). For a portion of the time the Siemens furnaces are employed in making all steel, the ingots of which are compressed into cylindrical shape by hydraulic power. Two of these, still warm from the press, were lying on cars ready to be taken to the forging shop. They looked like two great saw-logs, being 4 feet 6 inches in diameter and 15 feet in length. The ingots are forged under powerful steam hammers into any required shape, some for armor plates, some for guns and gun casings, and some for shafts, cranks, etc. The armor plates are heated in low furnaces, forged flat, requiring frequent reheating before the process is completed, and afterwards shaped by hydraulic power and tooled by machinery. After being finished in this way they are fitted together on platforms so that when sent to the shipyards each piece is ready to be put into the place designed for it without further machining or shaping of any kind. The specifications are furnished by the Navy Department, and hardly any two plates of the same ship or of any two ships are alike. Many of the plates weigh 30 tons and upwards. The long guns are heated in an upright furnace, some of the forgings being 25 to 38 feet in length, and weighing 25 to 45 tons. They are forged under a steam hammer weighing 125 tons.

Material for the construction of shafts, cranks, etc.

It is not improbable therefore that nickel steel will soon be utilized in the making of heavy ordnance as well as armor plate; and the frequent accidents which have recently occurred in the breaking of shafts of the great ocean liners will doubtless suggest the manufacture of shafts, cranks and indeed all important parts of the machinery of passenger ships as well as battle ships of nickel steel.

ARMOR PLATE IN EUROPE.

Experiments in Great Britain.

We know much less of the purposes to which nickel steel is applied in Europe, for the reason that the Governments of that continent are much more secretive in the trials they are carrying on than is the Government of the United States. A year ago the British Secretary for the Admiralty informed Parliament that nickel steel had been experimented with largely, that extensive orders had been placed for nickel steel armor forming the secondary defence of battle ships now in course of construction, and that several are fitted with this kind of armor which has been proved sensibly superior to ordinary steel when used in thicknesses of three or four inches. But the officials of the British Admiralty have been much slower to acknowledge the superiority of nickel steel for armor plate purposes than were their brethren in the United States, although the first suggestion of the usefulness of the alloy for this purpose was made by James Riley. But the astonishing results obtained in the United States last year at Indian Head and at the Bethlehem proving grounds could not any longer be ignored, and on the 1st of November a test was made at Portsmouth on board the target vessel Nettle. Up to this date tests in Great Britain had been confined to all steel and compound armor plates manufactured by English makers; but in this instance the experiment possessed a two-fold novelty, the plate submitted to the ordeal being of a nature new to Europe and having been manufactured in accordance with an American patent. The London Engineer furnished this account of the trial:

A surprising test on board a target vessel.

The Engineer's account of the test.

"The plate was made of high carbon nickel steel harveyized, or harveyed, by carbonizing the face and hardening it with jets of water. We may state at once that we are not in a position to report trials of this class from independent observation. The series of trials on board the Nettle are carried out by Admiralty officers, and are in all respects trustworthy; but in the interest of makers who in various stages of these trials might submit plates of an entirely experimental character, no officer or other official is allowed to treat the results as public property. In point of fact they are regarded as confidential unless the manufacturers wish to publish them themselves. There is we think no reason to find fault with this system. Certainly manufacturers have been thereby encouraged to make experiments which they might otherwise shrink from attempting, and although doubtless the effect must be that the public hear only of successful results they hear of them on trustworthy authority, and a very fair idea is obtained of all such work as is sufficiently good to be admitted into the service; and this is what mainly concerns the public, and when the photographs officially taken are published little is left to be desired as to completeness of information.

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[11] Iron, February 24th, 1893.

"The trial in question is an important one. Photographs of the best Harvey plates tested in America have been printed by us. We pointed out then that the shape taken by the remarkable result achieved was the holding together of the plate under the wedging strain of five 8-inch projectile heads, which penetrated to a considerable depth. In fact the hard face due to the Harvey process caused the projectiles to break, and though the heads had impressed energy enough on the plate to penetrate to a considerable depth the plate, as we suggested, probably thanks in a great measure to the nickel in its composition, held wonderfully well together. Tresidder's plate, which was naturally compared with it, performed a slightly different feat. It broke up 6-inch projectiles in its face with very insignificant penetration. Thus the projectiles were more completely defeated, but they were much smaller. The Tresidder plate, be it observed, was in consequence of the complete defeat of the projectiles not submitted to the wedging strain which fell on the Harvey plates, and there is no evidence as to how it would have behaved under it.

"Clearly the link required from Harvey's point of view was to show that the plate face was capable of defeating the lighter 6-inch projectiles with as little penetration as in the Tresidder plate. This was needed, for the last Harvey plate attacked by 6-inch shot had certainly allowed their points in two cases to penetrate deeply; one side of the plate was in fact softer than the other. There was an explanation for this, but no explanation is as good as a successful performance. The success at Portsmouth therefore is, we venture to think, just what we want at the present moment, and we are endeavoring to obtain permission to publish the photographs, which as yet we have not obtained.

"A competitive trial at Ochta, near St. Petersburg, is expected to take place shortly, when the Harvey, Tresidder, St. Chamond and Schneider plates will be tested in a strictly comparative way by 6-inch forged steel Holtzer projectiles, fired with about 2,000 feet velocity. The Nettle trials consisted of an attack of three 6-inch Holtzer and two Palliser chilled iron shot, striking at a velocity of about 1,976 feet per second. The Palliser projectiles are expected to break up as a matter of course with comparatively slight effect. It is only latterly that the Holtzer shot have been similarly defeated. In the present instance they have, we understand, broken into small fragments with but little penetration."[12]

Another account was published in Iron, and this paper, after citing the statements of the U. S. Secretary of the Navy and the Chief of the Bureau of Ordnance on the trials conducted under their direction, went on to say:

Iron's account of the test.

"However much these positive statements might be discounted, it was impossible for the British Admiralty, considering the official authority on which they were published, to discredit them entirely. It consequently determined to submit them to a practical test, and with this object in view it entered into negotiations with the agents of the Harvey Steel Company of New York. Eventually Messrs. Vickers & Co. of Sheffield were commissioned by the Government to manufacture a nickel steel plate and to treat it according to the Harvey process by which extraordinary hardness is communicated to the surface, together with a proportionate amount of toughness, so that the increased brittleness which commonly attends the hardening of steel is prevented. This was the plate that was tested on board the Nettle. The experiment was in no sense a manufacturer's, but an Admiralty test. It is the only trial of a harveyized plate which has yet taken place in Europe, for although a similar plate has been manufactured by the same makers for the Russian Government, it will not be fired at until next week.

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[12] The Engineer, London (England), November 4, 1892.

"The trial, which was conducted by Captain Hugo Pearson of the Excellent, was witnessed by W. H. White, C.B., Director of Naval Construction, Admiral Colomb, General Geary, R.A., Captains Jenkins and McKechnie, of the Ordnance Committee, Colonel W. W. Barlow, late of Woolwich Arsenal, and other officials. The Harvey Steel Company was represented by Mr. Edwin W. Fox and Mr. Joseph H. Dickinson of New York, and the manufacturers by Messrs. Albert and Thomas Vickers. The plate measured 6 feet by 8 feet, with a thickness of 10½ inches. Its dimensions were consequently the same as those of other sample plates tested on board the Nettle, and though the representatives of the steel company expressed a wish that it might be attacked by a gun of larger calibre and greater ballistic properties than the one usually employed, the test for purposes of comparison was of the ordinary character consistent with Admiralty conditions. This consisted of discharging five rounds at the target from the six-inch breech loader. The charge was 48 lb. of E.X.E. powder, the weight of projectile 100 lb., and the muzzle velocity 1,975 feet per second. The rounds were fired in the following order: (1) Holtzer steel shell at bottom right-hand corner; (2) Holtzer at upper left-hand corner; (3) Palliser shell at upper right-hand corner; (4) Palliser at lower left-hand corner; (5) Holtzer in the centre.

The result an astonishing success.

"The result of the firing was an astonishing success, and completely verified the accuracy of the reports received from America with reference to the merits of the Harvey hardening process. Contrary to ordinary experience the Palliser projectiles appeared to do as much execution as the French shells, for although they splashed upon the plate on impact they made indents of about 1½ inch in depth. The Holtzers on the other hand appeared to weld their points into the target before bursting into a thousand incandescent fragments. Every one was completely pulverized. The most remarkable feature of the trial however was the fact that the plate withstood its punishment so well that not a single crack was produced—a quite unprecedented circumstance in armourplate experiments. Further trials with thinner plates are to be prosecuted at Portsmouth, and should these prove correspondingly invulnerable many of our obsolete armorclads might easily be brought up to date by superseding their thin iron protection by the new armor of equal thickness and weight, but of greatly superior impenetrability."[13]

Possible adoption of the harveyized plate by Great Britain.

It is not known what decision if any has been reached by the British Admiralty authorities with respect to future construction, following this trial of armor plate on the Nettle, but it is not likely that the value of the lesson will be wholly lost. The Engineer in commenting upon the First Lord of the Admiralty's memorandum on the naval estimates for 1893-4 says: "Doubtless advantage will be taken of the increased resisting power to penetration afforded by the harveyized nickel steel plates; and, as a diminished thickness of armor can now be carried, it will probably be distributed over a greater area. We have slowly but surely been emancipating ourselves from that curious predilection for a small patch of enormously thick armor, of which the Inflexible was the earliest example.[14]

The cost of nickel steel plate.

It is not likely that a pre-eminently naval power like Great Britain, which is now expending over $70,000,000 a year to maintain a navy adequate to her requirements, and building battle ships at a cost of $3,000,000 to $4,000,000 each for those of the first rank, will long be content to use any other than the best of material. Nickel steel plate will cost more than all steel plate, perhaps much more; but it will in part make up the extra cost in greater lightness and increased efficiency, and in the construction of battle ships efficiency is the point of first consideration. Referring to the cost of nickel steel armor plate to the United States Government the Engineering News of New York says:

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[13] Iron, London (England), November 4, 1892.

[14] Engineer, March 10th, 1893, p. 211.

"Prices obtained for armor plates by the Carnegie and Bethlehem steel companies, who are the only manufacturers in the country, may well excite the envy of steel-makers who hunt for customers for best structural steel at prices under $40 per ton. Bids were opened on February 5th at the Navy Department for about 7,000 tons of nickel steel armor plate. The prices bid by the two firms ranged from $520 to $885 per ton for the different sizes and kinds of plate specified. About $56 per ton extra is asked for treating the plates by the Harvey process. Making a very liberal estimate for the cost of manufacture, it looks as if the profits on this order alone ought to go a long way toward repaying both the companies for their original expenditure on their armor-making plant. It is of interest to notice also that at an average price of $600 per ton the armor for the new line battle ship Massachusetts will cost about $1,225,000. The total cost of the vessel was estimated at $3,020,000."

The total quantity of armor plate required in the construction of this ship is 2,042 tons, the nickel contents of which would be at 3¼ per cent. (if gross tons are meant) not quite 150,000 pounds. Assuming the price to be 50 cents per pound, the cost of nickel contents in the plate will not exceed $75,000 (or $46,750 at the cost of nickel oxide). Unless then the cost of making nickel steel is vastly greater than of other alloys the question of cost of nickel steel plate will not long stand in the way of its adoption by Governments which are persuaded of its superiority. Nor is it likely that the Carnegie and Bethlehem works will long continue to enjoy a monopoly of supplying this plate to the Government at $600 per ton.

Tests in Russia.

The tests conducted by the Russian officials at Ochta were made upon one French and two English steel plates and a Vickers-harveyed nickel steel plate, and in commenting upon this trial the London Engineer reports the latter "to have altogether beaten its competitors."[15]

Effect of a general adoption of nickel steel armor plate on the production of nickel.

With all this evidence to demonstrate the value of nickel as an alloy with steel in the construction of war ships, the chances would appear strongly to favor its being so used by the navy building powers. Yet the demand for the metal would not be enormously increased if all the navies were to be reconstructed with nickel steel for armor plate; it would not be necessary perhaps to more than double the present production.

OTHER USES FOR NICKEL.

Whence then is an increased demand for nickel likely to arise? What other purposes give greater promise of consumption than the making of armor plate and ordnance? A few of these may be indicated.

Material for boilers, engines and locomotives.

As an alloy of steel the greatest use of nickel may be found in the making of boilers, engines and locomotives and structural material generally, where it is of vast importance to combine lightness and strength. In a large Atlantic liner for instance the plates of the boilers are one and a half inches thick, and enormous force is required to bend and rivet them, in which operation the plate is likely to be weakened by fracture, the lines of which are not always visible. If made of nickel steel alloy the plate would require to be little more than half the thickness, and while the boiler would be more easily and securely made, it would be but one half the weight—a very important item where there are twelve or thirteen huge boilers in the hold of one

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[15] The Engineer, March 24, 1893, p. 256.

would be as great, and it would be less liable to corrode.
e more, but its life would be lengthened.[16]
f parts of locomotives and steam engines, as well as in the
ks and shafting, nickel steel has also decided advantages
ocomotive is worth perhaps $100 per ton, and where the
ade up of the wages for labor as it is in the case of a loco-
tion to the cost of raw material is of little consequence.
notives, such as axles, of which everybody is so much
ork, etc., could be made of not much more than half the
just as strong.

erable quantity of nickel being used now in Great Britain
countries, but the trade is carried on quietly, and perhaps
o could give information about it besides the manufac-
ers, who generally know for what purposes their custom-
tal. It is quite possible that locomotive tires are being
steel in Germany, and doubtless a big trade will be done
ms likely that these German nickel steel tires are dis-
English make, but if so it will not be long before Eng-
e material.

Quiet use of the metal for various purposes.

ernment has been using a large amount of nickel in one
t chiefly in making experiments. A firm in Glasgow got
nonths ago which took up 20 tons of nickel, and this
garded as an unprecedented order ten years ago. But the
is conservative of new methods, and its officials must be
e advising a change from good to better.

British Government purchases for experimental objects.

o, when the production of nickel was 1,000 tons and the
$1.20 per pound, the chief if not only uses of the metal
ver, body for electroplating and for coinage. Its present
with the difference that coins are now being made of pure
nickel alloy as formerly. The Austrian Government
for this purpose, and it is rumored that they have given
mpany an order for about 3,000,000 pounds. It is only
who profess to know say that the company has received
it is probably for a larger quantity, spread over five or six
rs ago this French company refined 300 tons a year; to-
out 4,000 tons, having got the bulk of the expansion. It
improving its processes, and a great factor in cheapening
the increase of production. But of course many blunders

Chief uses of the metal twelve years ago.

The French nickel company's enterprise.

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n, manager of the Dominion Mineral Company's works at Sudbury,
through smelting New Caledonia ore, which is free from sulphur,
eel was made. "Garnier had a high furnace similar to an iron blast
s nickel ore through that furnace and smelted it as if it was iron ore.
lly of the iron and nickel in the ore was got out—though there was a
ckel and iron in the slag—and the result was a very good ferro-nickel,
ng of nickel steel by Mr. Marbeau, then one of the Directors of Le
e Ferro-nickel Company in France, at or near the German frontier.
the Steel Company of Scotland to experiment with nickel steel, and
r, told me that if it had not been for his company stopping him they
all the boiler plate in Scotland of nickel steel. But the trade got
had enough to do without experimenting."
nication Mons. Jules Garnier, the French metallurgist who has been
with the development of the nickel industry, gives the results of a
September, 1892, at the Cleveland Rolling Mill Company's works,
e quality of steel with and without the addition of nickel. The two
he amount of nickel added to one of them, the quantity being about 3
d of manufacture and the charges of both heats were absolutely
or both heats were rolled into boiler plates under ordinary conditions.
lowing general results: (1) Nickel steel has on an average a higher
400 lb. per square inch, or nearly 31 per cent. (2) Nickel steel has an
h greater by 10,400 lb. per square inch, or an increase of about 20 per
is not reduced by the presence of nickel. The nickel used was made
e Brooklyn Nickel Works, near Cleveland, a refinery built according
arnier.

have been made. That is inevitable in dealing with any new enterprise of this kind, the details of which must be mastered experimentally. The producer of pig iron, copper, gold or any other of the staple metals, can usually sell his metal as fast as it is produced to some person or other. If the price is made a little less than market rates, some one will take it; but the man who produces refined nickel must hunt up his own customers, and they are few in number. The demand today is not so great as the supply, but so soon as the metal is produced at 35 or 36 cents per pound instead of 42 the consumption may be expected to grow rapidly. And no doubt it is possible to sell nickel at these prices if the requirements of the market would justify operations on a larger scale than appears to be prudent to enter upon now. A thoroughly practical man says: "I can lay my hand on a mine tomorrow that would show a splendid result at these figures, but it is not every mine that can do so."[17]

Lower price will give an impetus to demand.

Rolled nickel for plating or welding.

Several years ago Mr. Wharton of Philadelphia, as already mentioned, began the plating of material by rolling refined nickel into thin plates and then pressing or welding it on both sides of a sheet of iron or steel; but he does not appear to have developed this application of the metal into a regular business. The process gives a very good article, but it is a little troublesome. A slab of nickel and a slab of steel may be rolled together so as to show a steel face upon one side and a face of nickel upon the other; or nickel may be rolled upon both sides of the steel, and when planished it presents a very attractive appearance. But results almost equally good as regards appearance may be obtained by dipping or electroplating, and the rolling process has not therefore come into general use.

Body for electroplate and white metal alloy.

At the present time the most promising uses of nickel are for the manufacture of body for electroplating, and the making of white metal alloy which does not require electroplating. If 25 or 28 per cent. of nickel is added to a white metal alloy the material is nearly as good as silver plate, and it can be kept clean with infinitely less trouble, besides being of uniform color and quality throughout the whole of its substance. A cheap electroplated article will cost as much as or more than a solid white metal one, and after the coating has worn it is an unsightly thing of patchy yellow. Door fittings if made of white metal would cost perhaps 10 per cent. more than brass; but they would always be bright and clean, and easily kept so. A gas bracket weighing 10 pounds, if made of white metal instead of brass, would consist of $2\frac{1}{2}$ pounds of nickel and $7\frac{1}{2}$ pounds of brass, the former costing

Uses of white metal.

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[17] The New York Engineering and Mining Journal of May 13th, 1893, says: "One thing definite may be said, we think, about nickel. The decline in its price which has taken place during the last two years will be maintained, and in all likelihood it will go still lower. There has been recently an industrial revolution in this metal equal in importance to that which followed the opening of the mines in New Caledonia. The discovery of the Sudbury deposits, and the Orford process by which nickel-copper matte can be cheaply and successfully treated, have made America independent of the world for its supply of nickel, and it now threatens the European markets, the cost of production having been brought below that of the metal of New Caledonia. European metallurgists have not been standing still however, for an improved process, the invention of M. D. Levat, formerly director-general of the Société le Nickel, has already been put in operation at Havre, France. This is a dry process; indeed, it may be said that the day of wet processes for nickel-winning is past."

The Engineer of London, Eng., of January 6th, 1893, also says: "The remarkable discovery of the volatility of nickel in carbonic oxide, due to Mr. Ludwig Mond, is according to a statement of the discoverer to be utilized upon a commercial scale, but it is not known whether the works have as yet been started. The older processes of obtaining the nickel have been improved by the adoption of continuous reduction furnaces, instead of crucibles, and in other details without much alteration of principle, and particular attention has been paid to the production of ferriferous metal for steel makers by Mr. J. Garnier and others; the modern practice of nickel smelting so far as it can be made public having been treated in considerable detail by M. Levat. In consequence of the large supplies coming from Canada and New Caledonia, the price of the metal has continually declined in spite of the new demand in Europe for military purposes, about 500 tons per annum being now required for the bullet casings in the new small arms ammunition. The alloy, one of nickel to four of copper, used for this purpose seems to possess many valuable properties, and it has been suggested as a substitute for copper in locomotive fire-box plates."

75 cents, or $1.80 in all. There is perhaps $10 worth
hat the increased cost through putting 25 per cent. of
be only a fraction of the total cost, while a handsomer
easily kept clean would be the result. Hotel bath and
., are now being made of white metal, and one manufac-
untry is said to turn out $1,000,000 worth in a year.
ade growing up." a gentleman engaged in the production
ne, "in the displacing of brass for lamps, chandeliers,
d railway carriage fittings, etc. White metal for these
aking the place of brass. It is dearer, but it is ever so
tier and easier to keep clean; it tarnishes very little and
tore its planished appearance, whereas brass requires con-
ep it bright. I have seen a butcher's shop in the old
which were wholly lined with white tiles, and all the fit-
s and nails were of white metal. The effect as seen by gas
was very fine, and it really enabled the butcher to add a
his beef. The white metal trade is the one we prefer."

Bullet casings of nickel-copper.

nd for the metal in Europe is in the making of bullet
rms ammunition. For this object an alloy of one part
s copper has been adopted, and factories producing ammu-
mall arms are requiring now 500 tons of nickel annually
of bullet casings alone.

Misapprehension regarding the demand for nickel.

rehension however prevails as to the demand for nickel.
declare that there is no limit to the quantity which the
of absorbing, and that some cause of policy, or want of
terprise is blocking the wheels of progress in the Sudbury
Sudbury was in the United States, we are sometimes
ld be alive with prospectors, mining camps and smelting
capital would be invested there, millions of tons of ore
l treated annually, refining works would be established,
d supply the world with the pure metal. Such is the
rs, and men who have mining locations to sell. But men
do not speak in that way; neither do men who have a
ndustries grow. On this subject I have obtained a short
Ian Cameron, manager of the Dominion Mineral Com-
man of large experience in nickel:

Responsiveness of consumption to a drop in price.

rice which took place eight or nine years ago, when nickel
er pound to 2s," Mr. Cameron says, "led to such an
nd that we could not supply it. When I built the old
the French company at Kirkintilloch in Scotland I com-
nd was then instructed to put up other two. I actually
h twelve the company could not until the slackness of a few
the work. The furnaces are small, and together they run
month. The ore is peculiar; it contains about 8 per cent.
ot lend itself to treatment in large quantity. If it could
the Sudbury ore the furnaces could run through an enor-

The present supply greater than the demand.

hink the supply of nickel is greater than the demand, and
on there is no greater expansion of the industry in this
Caledonia. The demand is not by any means unlimited;
e our trade as we go along."

e was an active and fast growing demand for nickel, miners
ould be found ready to supply it; and owing to the posi-
this Province and the great extent of the deposits capi-
be persuaded to invest money for mining and treating the
re prospect for unlimited sale of the product and of large
d. There is no hindrance to investment in Ontario, and
ge workable bodies of nickel ore this Province as far as

No hindrance to investment in Ontario.

Some drawbacks to be overcome.

yet known possesses a monopoly of it on this continent. There are drawbacks, but they are not insurmountable. As regards two or three of these I quote again from Mr. Cameron :

New Caledonia ore and its preparatory treatment.

Cost of labor in Ontario.

Duty on coke.

Royalty.

"The supply of nickel in the Sudbury district is unlimited, and there are a great many properties which have not been opened up. The New Caledonia ore, some of which occurs as a silicate and some as an oxide, averages as taken out of the mines from 5 to 6 per cent. of the nickel. I have got ore from there testing 25, 35 and 40 per cent. of nickel. This ore cannot be washed ; it can only be cobbed or picked. The native laborers are set to cob it ; they are good enough for that, and men, women and children may be employed at this work at a very low rate of wages. One trouble in this country is the dearness of labor, which costs as much as fifty per cent. of our whole expenditure. The duties upon stuff we buy also run up to a high percentage ; for example, the duty on coke amounts to 8 or 10 cents per ton of ore. The net value of 3½ per cent. ore after paying all costs at present selling price cannot be more than $1 per ton, the royalty on which at 3 per cent. would be three cents per ton. The duty on coke therefore is three times as much as all that would be paid to the Government for royalty."

As regards refining, Mr. Cameron says :

Refining.

"I do not know that it would be a very great advantage to have the refining of nickel done in this country. According to present practices acids are required, and these cannot be bought as cheaply here as on the other side of the Atlantic, and there are other things that we would have to import. Another disadvantage is that freight charges on refined nickel going to Europe would be greater than on matte. The rate on 100 tons of matte containing 50 per cent. of nickel would be $6 or $7 per ton ; but owing to risk of carriage 50 tons of refined nickel would not be carried at $12 per ton. I do not think there is much hope of refining nickel in this country until the consumption here has greatly increased, or until chemicals and other necessaries in refining can be bought as cheaply as in England or France, or until a successful dry process has been introduced. We could not refine here according to present practices and under existing conditions and hope to sell the nickel in Europe, as there is a heavy duty on the fine metal in France and Germany as well as in the United States. There is of course none in Great Britain."

No cause for discouragement.

Progress of the industry in Ontario.

In the present state of the nickel industry there is no well-founded cause for discouragement, except perhaps in the minds of extreme optimists with locations of unknown value on their hands to sell. Remembering that it is a comparatively new metal, and that until a few years ago its ore was scarce and hard to treat, the rank to which it has already attained is calculated to excite a feeling of wonder. The progress of operations in this Province in view of every circumstance, and especially of the fact that the largest refining concern in the world is also chief owner of the only mining properties which can compare in richness and extent with those of Ontario, has certainly been as active as the state of the market for the metal would seem to justify. Mining and smelting the ores had their beginning here less than seven years ago, yet measured by the number of men employed, the amount of wages paid for labor and the value of product last year there are only six iron working industries of the Province, as shown by the census of 1881, which exceed this one ; and among those are such old and stable industries as agricultural implements, blacksmithing, and foundry and machine shops. Of iron mines there is not one that is worked, although we have iron ores in great abundance ; neither is there one blast furnace to smelt iron ore, although we consume in the Province upwards of 300,000 tons of pig iron every year. All the indications point to a steady increase in the consumption of nickel ; and the number and variety of new and valuable uses which are being found for it give assurance that the industry is firmly rooted and will grow.

VIII.

THE METALLURGY OF NICKEL.[1]

By Mons. David Levat.

Garnierite, the nickel ore of New Caledonia.

Nickel is found in New Caledonia in a single mineral, Garnierite or Noumeite, a hydrated silicate of nickel and magnesium, of a bright apple-green color when pure, which is deposited in concretionary masses or cratings, in the fissures of a serpentine rock. This silicate is not a product of secondary decomposition, no traces of sulphides or arsenides of the metal having been found even in the deepest workings, and the mode of occurrence indicates clearly that the mineral has been deposited by water in the form in which it is now found. In a collection of specimens brought to Paris by Mons. Peletard, an engineer who has lately published a geological map of the island, impressions of insects have been found which are referred to living forms. The distribution of the mineral through the serpentine matrix is not an arbitrary one, it being always found at or near the contact of the rock with the red clays, filling basins or cavities in the rock, but never in the clay itself. These masses of clay are products of the decomposition of the serpentine, and contain all its constituents, in addition to manganese, cobalt and chromium. The thermal springs that have given rise to these clays follow lines of fissure having a general northeast and southwest direction. These clay deposits, which are often covered by considerable deposits of oolitic brown iron ore, contain irregularly stratified masses of cobaltic manganese ore, with 2.5 to 3.0 per cent. of cobalt and chromic iron ore, a granular or so-called alluvial form, which latter mineral is also found in veins in the solid serpentine.

Occurrence and mining of the ore.

The nickel ore, which is newer in origin than those of manganese and cobalt, is found as a vein matter in hollows resulting from the shrinking of the red clay from the sides of the rock-funnel enclosing it. These veins vary very much in size, the maximum breadth being about eight metres; but in some cases the whole of the rock is filled with small veins of mineral, so that it may be worked as a whole up to a thickness of 250 feet. Only the larger veins in the hard rock can be worked by systematic mining, as the walls are very irregular and may easily be lost in driving levels; by far the larger number of the workings are in open cast, at altitudes varying from 300 to 600 metres above the sea level, where it is easier to follow the richer developments, and with a comparatively small preliminary outlay to make provision for some years of quarry working in the same locality. The preliminary working is mainly in the direction of removing the red clay, which can only be imperfectly separated from the ore by washing; and the iron ore it contains, if left behind, impoverishes the yield of nickel, besides being objectionable in the smelting by reason of its adding alumina to the charge, which is sufficiently refractory from silica. These works are often a source of considerable expense on account of the falls caused by the heavy spring and autumn rains and the difficulty of obtaining sufficient labor.

Classes of labor employed at the mines.

As regards the latter point, apart from free white men, who are mainly employed as artisans or sub-managers, at the Australian rate of wages of 12s. o 16s. per day, four different sources of labor are employed, namely, assigned convicts, those on restricted leave, natives and New Hebrideans of the Kanaka ace, and Chinese, Annamites and Tonkinese. The first two classes are very unsatisfactory, and the Kanakas, although of value for transport and lighterage service, are unfit for mining purposes, being unable to stand exposure to the mountain air, and as a rule the tribes object to working about their own homes, so that the work is principally done by immigrants from the New Hebrides; while the labor in the coffee plantations of the latter islands is largely furnished by New Caledonians. The Chinese are valuable workmen, but the supply from China proper, owing to political and diplomatic complications, has of late years been completely stopped; but latterly natives under contract have been brought from Tonquin, and the result appears to be satisfactory, their work, costing about 2s. 9d. per day, being better than that of convicts at nearly double the price.

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[1] This is an extract from a long general memoir on the production and uses of nickel and ts alloys, which appeared in the Annales des Mines, Paris, 1892, published by authority of he Minister of Public Works. M. Levat is a civil and mining engineer, and was formerly director-general of the Société le Nickel.

Dressing the ore.

The mineral is carefully sorted by hand at the quarries and divided into rich and poor qualities, the former containing 8 per cent. and above of nickel, and the latter all below that limit. As the hill-side workings are entirely without water, dressing operations can only be carried on in the lower ground. These are confined to simply washing away the red clay, and even this preparation cannot be carried too far without risking considerable loss (up to 3 or 4 per cent.) in the mud washed away. Hence the necessity of carefully clearing away the waste before working the mineral. The quarry waste, containing 3 to 4 per cent. of nickel, is not utilized.

Transportation from mine to shipboard.

The conveyance of the mineral from the mines to the coast is done principally by ropeways, which are mostly of the simplest construction. When the produce is not more than 7 or 8 tons daily, the selected ore is placed in sacks holding from 100 lb. to 120 lb. attached to a hardwood carrier, which is placed on the rope and allowed to slide down, for which purpose a slope of at least 18 degrees is necessary, the empty sacks being carried back by hand or mules, together with the carriers, which make 15 or 20 journeys before they are worn out. The spans of the rope range from 500 metres to 600 metres, and in some instances 800 metres. From the lower stations the carriage to the shore is effected in carts or by railway, but these distances are never very considerable, as only the mines within a zone of a few miles from the coast are actually worked. The embarkation is done in lighters carrying 12 tons to 15 tons each, the cargoes being sent direct to Europe, or by transhipment at Noumea and Sydney. During the wool-shipping season steamers and sailing vessels carry ore and regulus at nominal freights as ballast. The direct shipment in large sailing vessels is less feasible, owing to the numerous accidents that have happened in navigating the reefs forming the coast, and the harbor of Noumea being the only one lighted, the other ports can only be approached in daylight and with a fair wind.

Conduct of mining operations.

Mining operations are conducted either by companies with sufficient capital to provide complete means of transportation, or by single miners who work on their own account on exposures which offer facilities for immediate labor and who deliver the ore on specified conditions. The price at which the ores are sold on the spot naturally varies with the market value of nickel and with their contents, rising rapidly as the latter increases, being better able the richer it is to bear the many charges which the ore must sustain before being smelted and refined. Advances in provisions and goods are generally made to isolated miners or small associations of miners, and also even advances of money, which they reimburse by delivery of the ore, so that any active miner in New Caledonia may work with success, even without capital.

Mining rights.

The acquisition of mining property is easy and open to all, thanks to the special mining regulations established in the colony by decree of the governor dated 13th September, 1873. They follow principally the mining laws of Australia, which give an absolute right to obtain any lodes discovered, but have been modified by the decree of 22nd July, 1883, which has remodelled entirely the mining legislation of the colony and constitutes the unique law at present in force.

TREATMENT OF GARNIERITE.

The treatment of the mineral has undergone several modifications before arriving at the present practice. The original plan of Mons. Garnier was to treat it like iron ore by running it into pig metal, which was afterwards to be refined in a reverberatory furnace to ferro-nickel. For this purpose two blast furnaces were built at Noumea, and a refinery with two Siemens furnaces at Septemes, near Marseilles. Only the first part of the process gave satisfactory results, nickel-iron pig metal having been obtained from the richer lumps, ores averaging 9 to 10 per cent. of nickel of the following composition: Nickel, 65 to 68; iron, 29.5 to 23.0; sulphur, 1.5 to 2.5; silica and carbon, 3.5 to 5.0; and other matters 1.5 to 2.5 per cent. But it was found to be impossible to refine this in the reverberatory furnace owing to the presence of sulphur, which has an extremely high affinity for nickel. It was therefore necessary to revert to the old method of concentrating the metal as sulphide by the addition of pyrites or sulphur. The average composition of the ore available for smelting was: Silica, 45 to 50; iron, 16 to 14; nickel, 8 to 7; magnesia, 12 to10; alumina, 3 to 5; water and oxygen, 16 to 14 per cent. This requires from 25 per cent. to 30 per cent. of bases (oxide of iron or limestone), besides a sulphurizing material. As neither gypsum nor pyrites, free from arsenic and copper, were available for the latter purpose, the charge for the blast furnace was made up as follows: ore, 1000; coral, 300; sulphur, 35; small coal or coke 75 kilogrammes. The greater part of the sulphur passed into the regulus, and a fluid slag was obtained with 48 per cent. of silica, 12 to 13 per cent. of iron, and not more than 0.40 to 0.45 per cent. of nickel; but the local smelting was given up owing to the difficulties in procuring coke, and now the ores are for the most part smelted in England, alkali waste being used as flux.

Garnier's early method.

Local smelting abandoned, and the ore shipped to England.

The consumption of coke is about 20 per cent. of the weight of the charge, or about 30 per cent. of that of the ore treated. Small-sized water-jacket cupolas, smelting from 25 to 30 tons in twenty-four hours, are used. The product contains nickel 50 to 55, iron 25 to 30, and sulphur 16 to 18 per cent., the latter being necessary to make the regulus sufficiently brittle to be easily powdered. The subsequent concentration may be done either in the reverberatory furnace or the Bessemer converter. In the former two calcinations, followed by fusion with quartz-sand, are necessary for the removal of the iron. The furnace treats two tons in 24 hours, with the consumption of an equal weight of coal. The operation, which lasts eight hours, is controlled by sampling during the progress, and is stopped when the iron has completely disappeared in order to prevent loss of nickel in the slags, which however are not thrown away, but are returned to the ore-furnace, as they form an excellent flux, besides containing 2½ per cent. of nickel. By the first concentration the iron is reduced to 2.5 to 3 per cent., and by the second to 0.5 to 0.75 per cent., the sulphur being kept to 16 per cent. at least. In the Bessemer converter the concentration is more rapidly done; a charge of one ton of regulus melted in a cupola is introduced into the converter and blown with air at a pressure of about forty centimetres of mercury. The temperature rises from the combustion of the sulphur, and sand is added to flux the iron. If the proportion of the latter metal does not exceed 36 per cent. it may be completely removed in about one hour and twenty minutes, but with a larger quantity the bath should be skimmed after blowing for twenty-five minntes and fresh flux added, as the fining will be imperfectly done if too large a quantity of slag is retained in the converter. When the slags begin to show signs of containing nickel-oxide the refined metal is poured into moulds. Arsenic, antimony and silver are removed either in the slags or by the blast; cobalt remains with the nickel-sulphide. The converter slags are much richer than those of the reverberatory furnace, containing from 14 to 15 per cent. of nickel, mostly as shots of diffused regulus, which may in part be collected by

Furnace treatment, and subsequent concentration to eliminate iron and sulphur.

running the slag into conical pots and separating the cake of metal at the bottom. The whole of it must in any case be returned to the ore furnace. Attempts have been made to continue the blowing up to the complete removal of the sulphur to produce a material that would only require a final reducing treatment to obtain pure nickel. This has however been found to be impossible, owing to the high affinity of nickel for sulphur, the heat developed in such an after blow being less than sufficient to counteract the cooling effect of the air, and as the product when free from copper has a high melting-point, approximating to that of iron, it sets very rapidly, and blocks up the tuyeres.

Refining the regulus.

The refined regulus, whether obtained from the reverberatory furnace or the converter, consists essentially of nickel-sulphide (or nickel and copper sulphides, if obtained from pyritic ore like that of Canada), with not more than 0 50 per cent. of iron and the same proportion of other foreign matters. It is crushed to pass a 65-mesh sieve, and charged in quantities of 600 kilogrammes upon the bed of a reverberatory calciner 10 metres long and 2 50 metres broad, with four working doors on one side, forming a layer about two inches thick, which is constantly rabbled and moved gradually from the flue of the fire-bridge end. The operation lasts eight hours with pure nickel-sulphide, and only six when the regulus contains copper. The consumption of coal is 2,000 kilogrammes for 2,400 kilogrammes of material roasted. The temperature is kept to a dull redness, except towards the end, when the furnace is raised to a bright red heat. The finished product, which should not contain more than 1 per cent. of sulphur, is ground to pass a sieve of 120 mesh, and subjected to dead roasting in a furnace of the same breadth as the preceding one, but with a shorter bed. The charge is 500 kilogrammes renewed every six hours, and the temperature is kept at bright redness; three tons of coal are burnt in 24 hours. The product is nickel oxide, or nickel and copper oxides, and should not contain more than 0.40 per cent. of sulphur.

Reduction of nickel oxide.

The reduction of the oxide is effected by mixing it to a paste with flour or other organic matters, dividing into small pieces when dried, and strongly heating with charcoal powder. Formerly the paste was cut into cubes of 12 to 15 millimetres, but in France disks of regular shape, 50 millimetres in diameter and about 15 millimetres thick, made in a press, are preferred. They must not be made thicker, or the reduction will be imperfect in the centre. The Chinese, who are somewhat considerable consumers of nickel, prefer to have it moulded into ingots similar to those used as money in China. Formerly the reduction was effected in crucibles holding 50 to 60 kilogrammes in a gallery or reverberatory furnace, but owing to the imperfect and irregular heating the process was very wasteful of fuel, and the pots did not last for more than five or six operations. This method has therefore been abandoned in favor of furnaces working continuously. The first of these is a large muffle 3.5 metres long and 1.8 metres broad, heated by the flame of a gas furnace, which is passed several times around it by a series of spiral flues. The shorter sides are closed by balanced doors, and the iron pots containing a mixture of oxide and charcoal are subjected to a gradually increasing heat for 24 hours, being entered at the coolest side and pushed gradually nearer to the fireplace. This with mixed oxides gives a coherent product; but pure nickel oxide, although it is reduced by carbon at a comparatively low temperature, must be subjected to a temperature of 1,100° or 1,200° for four hours to obtain the coherent metallic character required by the customer; and as such a heat is unattainable in the muffle, the operation must be finished in a crucible.

An improved plan.

Another and more improved plan of reduction is in a regenerative furnace resembling that used for reducing zinc oxide in Belgium, but having retorts open at each end. The mixture of oxide and charcoal is charged by a semicircular scoop at one end, and when finished the charge is pushed out at the other end into closed receivers, where it is allowed to cool out of contact with

with 22 retorts is capable of reducing 1,500 kilogrammes
00 kilogrammes of nickel-copper oxides in 24 hours, the
kilogrammes requiring ten hours in the furnace in the
n the second case. About two tons of coal are required
enty-four hours, and the work is done by two men per
he reduced metal is sifted to separate the cubes or disks
oken masses, which are afterwards collected by a magnet.
ned by friction upon each other in a rapidly rotating
er is added in packing the barrels to make up the exact
mmes.

important recent applications of nickel is that of the
, copper 80 parts) for the casing of bullets for the small-
Nickel-copper alloy.
modern armaments. This combines a higher tenacity
brass with a high co-efficient of elongation, the former
kilogrammes per square millimetre, and the latter 25 to
eptionally as much as 39 per cent. in the metal as cast.
ngation increases with the freedom of the alloy from iron.
ensile strength is increased to 60 or 62 kilogrammes and
inished to 3 or 4 per cent. When annealed under the
itions the strength is 30 to 40 kilogrammes and the
er cent., compared with copper, where the corresponding
rammes and 34.1 per cent. The annealing of this alloy
eration, requiring special manipulation, the details of
t secret by the manufacturers. The principal object is
d this according to the author may be most effectually
e sheets in the annealing piles by sheets of cardboard,
during the process. If badly annealed, the mechanical
l in a remarkable manner, the burnt metal having a ten-
logrammes, with only 1 per cent. elongation. In a gen-
g is considered to be bad if the tensile strength is below
the elongation less than 30 per cent. The elastic limit is
mmes when well annealed and 45 kilogrammes when
n the rolls. The ready malleability of this alloy seems
rly suitable for locomotive fire boxes, and plates for this
ed by the Societe des Metaux at the last Paris Exhibition.
eats of the nickel deposits of the Sudbury district,
cts in connection with the geological formations in which
manner of occurrence, etc. As to the mining operations

TREATMENT OF SUDBURY ORES.

the Sudbury deposits is concentrated in the hands of
ssessed of ample means and improved appliances. Only
Extent of the deposits.
he railway are at present worked, but there are many
ll unknown, unworked or insufficiently developed, owing
t nature of the country. Nevertheless, according to an
ed to the Secretary of the United States Navy in Octo-
been exposed at that time in the various workings a
d to contain not less than 650,000,000 of tons, the total
that time for a period of two years only being about
figures sufficiently indicate the economic and industrial
as a producer of nickel. The average contents of the
4 per cent. of nickel and about the same of copper. The
Copper Company appear relatively less rich in nickel
minion Mineral Company, but both seem to increase in
metals in proportion to the depth of the workings.

Smelting the ore.

. . The smelting of the roasted ore is the most interesting part of the local treatment of the Canadian mineral. It is done in large water-jackets with steel plating of 3 millimetres and of elliptical form, made in one piece from the hearth to the charging door. The hearth itself is closed by a plate of iron covered with fire-clay. Furnace No. 1 of the Canadian Copper Company smelted in 259 consecutive days 31,268 tons of ore, an average of 120 tons every 24 hours. No. 2 ran for 73 days, smelting 9,740 tons, or 133 tons every 24 hours. The low height of the furnace avoids the reduction of the iron and the formation of "wolves." The coke consumed during the campaign above mentioned was 5,107 tons, which smelted 41,000 tons of ore, an average of 12.5 lb. of coke to 100 lb. of ore. The coke, which contains 10 per cent. of ash, comes from Pittsburgh by lake and rail, and costs delivered at the smelters 35 francs per ton. The matte produced in the same time amounted to 5,059 tons, about 12 per cent. in weight of the ore smelted, almost exactly the same proportion as that of the coke used. In other words, 1 ton of matte requires for its smelting 1 ton of coke. The slag is very basic, as the following analysis will show :

Matte and slag.

SiO_2	38.00 per cent.
FeO	43.00
CaO	4.50
Al_2O_3	10 00
S	2.00
Ni	.45
Cu	.40
MgO	2.50
	100.85

At first the mattes contained more copper than nickel, which proved disadvantageous in their subsequent treatment, the refiners charging more as the proportion of the copper exceeded that of the nickel. In 1889 the mattes contained, according to the analyses of the Canadian Copper Company,

Cu	26.910 per cent.
Ni	14.140
Fe	31.235
S	26.950
Co	.235
Slag	.935
	100.405

By selecting out the purely copper ores for separate treatment the nickel contents of the matte have been increased. In February, 1891, the mattes contained

Cu	16.94	16.95	17.84
Ni	19.40	21.47	23.45

The charge in the Dominion Mineral Company's furnace is composed partly of purely nickeliferous ores produced by certain of its mines. That company's mattes contain

Cu	18 to 20 per cent.
Ni	24 to 26

Relation of cost of production to price of fine metal.

The cost of smelting at Sudbury may be estimated at between 8 and 9 francs per ton of ore. Manual labor comprises only about 2.25 to 2.50 francs per ton of this cost, notwithstanding its dearness. The workmen employed at the furnaces receive on an average 9 francs per day of eight hours. Each furnace employs per shift 1 fireman, 1 weigher, 2 founders, 3 men to take away the slag, and 3 shovellers. The entire plant is organized in such a way that the handling of the ore from the mine to the furnace is reduced to a minimum. In fact the ore is handled only four times from mine to smelter, and each delivery, save to the roast heap, is effected by means of hoppers with inclined bottoms discharging directly into waggons. As has been already stated the average cost of mining the ore is at present 10 francs per ton, thanks to the open workings, the output of which comprises a large part of the total production, and which enable the ore to be mined cheaply. This resource must in the future become exhausted and subterranean workings only resorted to, the cost of mining from which is about 15 francs per ton. This sum must necessarily increase in proportion to the difficulties met in the underground workings, and notably on account of the barren stretches, which will be considerable. It is true that there is good ground to hope for an increase in the nickel contents of the ore as the depth increases, but even on the basis of present results and a cost of from 20 to 25 francs per ton for mining and 10 francs for roasting and smelting it is evident that ores having an average contents of two to three per cent. of nickel and the same of copper will produce a matte in which the useful metals will carry a cost of 1 franc 50 centimes per kilogram of nickel contained, and 50 centimes per kilogram of copper; that is to say a cost very much lower than the probable market value of these metals in the future, all charges of refining being deducted.

Low cost of reduction to matte.

. . . To sum up, the Canadian ores, notwithstanding their relatively small percentage of nickel can produce this metal in the form of matte enriched to 20 per cent. at a very low price. This is due in great part to the ease with which the ores are treated and the richness of the deposits. The matte, besides nickel, contains copper, which must be separated by a distinct operation if it is desired to obtain pure nickel, while the mattes of New Caledonia do not require this supplementary process. It is true that these additional expenses are covered by the value of the copper, the refining of which is much simplified by the very fact of its separation from the nickel. On the other hand, the New Caledonia ore must go through a preliminary smelting before being given over to the refinery, while the Canadian mattes can be refined directly without a new concentration. These different considerations seem to balance each other, and it would seem that the two countries which are producing nickel at this time can strive with equal advantage so far as their respective cost of production is concerned. The advantage would certainly be with Canada if nickel were employed principally for making white alloys, as for this purpose it is only necessary to refine the nickel and copper together, but this method of employment seems to be more or less falling into disuse, and is being replaced by the use of pure nickel, especially for alloys with iron and steel.

Balancing considerations.

THE NICKEL OF COMMERCE.

Impurities and alloys.

The nickel of commerce contains in general 1.50 per cent. of impurities, the principal of which, iron, has no injurious influence in the uses to which it is destined. It contains also carbon in the free state and combined, oxygen, a little sulphur and other foreign matters derived from the wasting of the furnaces. Nickel-copper alloys contain about the same impurities. These alloys are delivered in the form of cubes or grains of different compositions, such as 90 per cent. of nickel and 10 of copper, or 75 to 25, but especially in the form of 50 per cent. of nickel to 50 per cent. of copper, approximately. The latter is a definite alloy which must always be taken as a starting point when one wishes to proceed with the manufacture of binary or ternary alloys of nickel. The makers of "maillechort," "argentan," "silverine," etc., usually buy their nickel in the form of the 50 per cent. alloy, and this combination is also the easiest to obtain from the refining of the Canadian mattes. At the same time, as the uses of nickel appear to be developing principally in the line of alloys with iron and steel, uses for which the presence of copper is inadmissible, it has been indispensable to obtain a method permitting of the complete separation of these two metals, and this at a cost not exceeding that of refining the Caledonian mattes, but taking into account nevertheless the cost apportionable to the copper as well as of the fact that the latter is partially refined by the nickel being separated. This question is all the more interesting to the nickel industry because the deposits of Canada form, as we have seen, a factor in their power of production equal to those of New Caledonia.

The question of supply.

One of the difficulties in the way of the employment of nickel in those industries which might consume large quantities, as for example the manufacture of steel, is the fear of a premature exhaustion of the nickel deposits and the uncertainty of procuring the necessary supplies without unduly enhancing the price of the metal. The possibility of employing the nickel of Canada, or, which is the same thing, the possibility of a complete and economic separation of the nickel from the copper, is therefore a problem interesting in the highest degree to the nickel industry.

The problem of separating nickel and copper.

A separation of this kind can hardly, *a priori*, be effected except by chemical means, otherwise the wet process. The question is not a new one, because in the old metallurgy of nickel this metal, almost constantly associated with copper and cobalt, was separated from these latter by various methods, which always made use of the wet process either partially or wholly. There will be found in the works to which I have referred at the beginning of this memoir the formulæ for the methods of treatment by which the separation was attained. These operations, which belonged rather to the laboratory than to industrial practice, were profitable only because of the high price of nickel and cobalt at that period. The copper was, so to speak, sacrificed, and the purity of the nickel was only of very relative importance on account of the uses to which it was destined. The presence in the nickel of a certain proportion of copper was not only not objectionable, but even served to conceal the troublesome effects of the arsenic and sulphur which remained in the metal. None of these methods could answer the end which was desired, namely, the complete separation of the copper from the nickel. It would be tedious to enumerate all the methods proposed or attempted with this end in view. Mons. Badoureau cited in his memoir a large number of them, applied it is true to the ores of New Caledonia, but they have since then become very numerous, and patents have been taken out and are applied for daily for the same object. I recognize only as interesting experiments the processes based on the electrolytic deposit of nickel in a liquor containing copper. It appears possible to produce this separation, basing the process upon the difference in the electromotive force necessary for the decomposition of the salts of copper on the one hand and those of nickel on the other, the latter requiring a much higher voltage than the former. . . . . It is then possible, theoretically at least, to maintain in a bath of the sulphates of the two metals an electric tension below 1.877 volts and deposit the whole of the copy without the nickel. This reaction has been studied by Messrs. Siemens and Halske of Berlin, but I do not know up to the present time of the industrial application of the method. The chemically pure nickel deposited by electrolysis does not appear to conform to all the applications of this metal. It is especially, owing to the absence of carbon, unsuitable for the manufacture of alloys, for which it is necessary to employ the carburetted nickels.

The electrolytic method.

Garnier's new method.

Mons. J. Garnier announces in his work which I have already cited the application by an important metallurgical establishment of the United States of a process for the separation of the nickel and copper in the mattes of Sudbury, patented by himself, but he does not give details on the principle of the separation. This establishment, actually in construction near Pittsburgh, applies the process to the mattes produced by the Canadian Copper Company.

At the establishment of St. Denis, belonging to the firm of Christophle, they treat the ores of New Caledonia by the dry method and by the wet method conjointly. The latter is applied notably to the cupro-nickeliferous mattes obtained by a first fusion with pyrites containing copper and nickel. It is besides an additional operation; the separation is performed in a hydrochloric liquor. They commence by attacking the matte with hydro-

then utilize the freed sulphuric acid for the precip-
er from the solutions obtained in a previous part of the
is precipitated by oxidizing it by calcium chloride and a
inally the nickel is obtained under the form of a greenish,
ed precipitate by means of milk of lime. This oxide can be
the manufacture of sulphate of nickel destined for electro-
calcined and reunited to the oxide obtained by the dry way
sed on for reduction.

Conjoint wet and dry processes.

ith the oxide of nickel precipitated by lime is that it always
uantity of the impurities of the milk of lime employed for
If liquid containing sulphates is worked with, one has more-
ience arising from the presence of the sulphate of lime
ater retained by the gelatinous precipitate of the hydrated
ery voluminous. This salt remains in the nickel throughout
d introduces during reduction sulphur into the metal. This
be avoided by precipitating the dissolved sulphate of lime
ium before effecting in the hydrochloric liquor the precipi-
el by milk of lime, or separating the sulphate of lime after
ating it in the crucible with carbonate of soda. The part
purified oxide, but both these methods increase the cost of
et way. This difficulty of the purification and washing of
kel precipitated by a base in a hydrated and gelatinous
the adoption of the wet process, properly so called, impos-
tment of large quantities, or at least makes necessary the
an extraordinary scale of precipitation vats and washing
ined with filter presses requiring much hand labor, to
product, the oxide of nickel, pressed into cakes, still con-
60 per cent. of water.

hmidt process completely overcomes this difficulty in this
ckel is separated without requiring any precipitation, and
n takes place in the body of very concentrated solutions.
into details of this operation, which I am not authorized to
e that in principle this complete separation is obtained by
copper by the nickel and the iron of the matte itself, and
on the one side the whole of the nickel in concentrated solu-
only be evaporated to be transformed into an oxide by
reduced by the ordinary process, and on the other side a
r which requires only to be refined in order to be put into
m.

PURE NICKEL.

Nickel of commerce treated in the crucible.

commerce, containing 98 or 99 per cent. of that metal, the
hich we have just described, is not properly speaking a metal.
nge of reduced particles artificially agglomerated, and conse-
cohesion. In order to study its properties and to utilize it,
melt it in a crucible, an operation which requires a high
much care, because nickel, which is unattacked by atmos-
ordinary temperatures, oxidizes very readily at a red heat,
solved in a bath of the metal renders the latter brittle. It is
avoid contact with carbon, which would give a steel or even
el with a considerably lower melting point. The operation is
rmed in a crucible under a layer of flux, and the metal is
r shell according to the kind of articles it is desired to
this way that cast anodes destined for electroplating are

kel is to be rolled there is added in the crucible a few minutes
small quantity of some reducing metal, easily oxidized, such as

magnesium, manganese or aluminium. Care should be taken to place this meta at the bottom of the crucible with a bar of pure nickel, or in refractory clay. It is probable that independently of the reducing action these oxidizable metals, especially aluminium, act on the oxide of carbon dissolved by the nickel, as has been shown in the recent works of Mr. Hatfield on the action of aluminium in the casting of steel. Pure nickel obtained under this form is malleable, ductile, and easily forged. Its tenacity is intermediate between that of iron and steel, and according to Deville its point of rupture is 90 kilograms per square millimetre. It melts like iron at a high temperature, softening at about 1,200 degrees. The presence of carbon renders it almost as fusible as cast iron. The density of the pure metal is 8.38. Its electric conductivity is almost exactly that of iron. We know too that nickel is magnetic. According to Poullet, it loses its magnetism at a temperature of 350 degrees. It is magnetized under the same conditions as soft iron. Under the influence of feeble magnetizing currents it is magnetized five and a half times more than iron, but with magnetic currents of considerable strength it is magnetized five times less. The question of the temper of nickel has not yet been completely studied. Denied by Boussingault, who probably had not at his disposal at that time (1878) nickel sufficiently pure, it has been recognized that nickel forms with carbon true steels and true castings. The question is at present being studied, and it is probable that in a short time the conclusions arrived at may be made public.

Qualities of pure nickel.

Nickel is rolled hot as easily as iron. It is forged, as before stated, and is welded to itself or to iron. This latter property has given rise in Germany, Switzerland and France to the industry of nickel-plating by welding two plates of given relative thickness, one of nickel and the other of soft iron, previously well scoured, by means of rolling them together. The two metals having similar coefficients of ductility preserve during the rolling their proportional thickness in such a way that one may obtain at will a plate of a tenth, a twentieth, etc. The iron may also be plated on both sides and in this condition employed in place of pure nickel for a multitude of uses and domestic objects, the more readily as this hot-plating, or more properly welding, has not the defect of scaling off during use as the electro-plated ware has. Nickel plated wire in virtue of the same principle may also be manufactured and drawn out to any desired number. The same operation, whether for the plating or the wire, can be carried on with nickel combined with copper. These sheets, plated on one or two faces, will take on a beautiful polish which is not affected by the air. They are employed notably in the manufacture of parabolic reflectors for lanterns in place of silver. The cost of these is much less than those made of silver, and their polish is as brilliant, although of a darker shade. They are also more difficult to scratch. Such sheets also admit of being stamped for the manufacture of cooking utensils, carriageware, etc.

Nickel-plating.

Independently of the plating, the pure nickel in leaves and threads is entering more and more into common use. As it is less malleable and less easy to melt or to mould than copper or brass, the appliances of the manufacturers who employ the latter metals are insufficient to utilize the metal, and on this account there is a certain delay in the manufacture of objects for domestic use. Nickel threads are employed very largely in passementerie. Lyons is the centre of a special industry of gilded and silver laces plated on nickel, which do not tarnish through use like those plated on white metal or brass.

Uses of pure nickel in leaf and thread forms.

Pure nickel is employed under the form of cast or rolled anodes in order to deposit on the surface of various objects previously well scoured a thin layer of electrolytic nickel, to which there is finally given a brilliancy by polishing. Becquerel was the first to make known a process of galvanic nickelling of metals by means of a neutral solution of the double sulphate of nickel and ammonia. This salt is still the base of the baths at present employed, the

Electrolytic nickel.

vary indefinitely. The important point is that the bath nd that it remains neutral during the whole operation. This ng in it the anodes of pure nickel, which are dissolved in netallic deposit upon the objects to be nickelled. The pro- equires a very strong current. A bath of 200 to 300 litres, es six Bunsen elements of 22 centimetres. For this reason iven to electric-dynamo machines. The nickel bath con- n aqueous solution of ammoniacal sulphate of nickel of 7 ay 70 or 80 grammes of metal dissolved in a litre. The n neutral to litmus paper. There is frequently added to it as the neutral salt of commerce, a mixture of phosphate f soda with ammonia. The phosphate and bicarbonate ctivity of the bath. In place of anodes of nickel, insoluble carbon may be employed, in which case the bath must be f ammoniacal salt of nickel. The foreign metals which th are precipitated by the daily addition of small quantities . The hot baths give the most brilliant precipitates, but se given by the cold baths. When the object is removed is dipped in hot water and then dried in sawdust, and cloth and polished by the burnisher.

New process of nickelling.

kelling has been done by the electro method. There is ed on a very curious reaction of nickel. Messrs. Mond, e have shown recently that if carbon monoxide be passed ning at a temperature of about 30 degrees, the two bodies ombination which may be condensed into a liquid boiling at nickel can be obtained by a reduction of the oxide by means s very volatile liquid can be dissolved in benzine and petro- r in solution it is decomposed with a brilliant deposit of nfluence of a slight elevation of temperature. In order to a coating of nickel they are immersed in a solution or in t an elevated temperature. If it is desired to obtain plates he electrolytic process or otherwise, depositing surfaces are ith a layer of graphite. The processes of M. Mond are the laboratory, and are based on an absolutely unexpected nteresting to note.

LOYS OF NICKEL AND OTHER METALS.

Nickel and copper.

ery easily with copper in all proportions. Its action is irst place on the color of the alloy. As its proportion cent. the metal whitens. At 15 per cent. the alloy is this proportion is only exceeded when it is desired to obtain . At 25 per cent. the maximum of effect is obtained. An s susceptible of taking on a beautiful polish, with a clear o that of silver. Air tarnishes this brilliancy, but with ess. Above 25 per cent. the increase of the proportion of ger any effect upon the color. The addition of a small gives an alloy of perfect whiteness, even when the propor- not surpass 16 per cent.[2]

"argentan" has a composition based upon this fact. Following is loy of "argentan" patented by Mr. Pirsch:

u	79 50	75.00	71.00
i	16.00	16.00	16.50
o	1.00	2.00	1.25
n	1.00	2.25	7.50
	1.00	2.75	2.50
l	.50	.50	....
e	1.00	1.50	1.25

s that of a true maillechort.

White metals.

There is a constant confusion among the names and compositions of binary, ternary and multiple alloys of nickel known under the general designation of white metals. Under the name 'maillechort' an alloy is made of nickel, copper and zinc, containing a maximum of 15 per cent of nickel. The remainder is composed of two parts of copper and one of zinc. 'Silverine,' 'argentan,' 'packfong,' etc., contain other metals as well, such as tin, bismuth or antimony, which impart fusibility and a fine color generally at the expense of ductility. A certain quantity of iron is usually added if the nickel employed does not already contain it in order to give hardness to the alloy. Zinc produces a similar effect. The binary alloy of 90 per cent of zinc and 10 per cent of nickel is easily reduced to a galvanic powder and sold for this purpose under various names.

Production of the alloys.

The preparation, fusion and especially the casting of these alloys are extremely delicate operations, demanding skilled founders in order to obtain regular ingots. Whatever may be the composition desired we must always commence by making an alloy of 50 per cent. nickel to 50 per cent copper, and a sufficient quantity of the latter metal is afterwards added to produce the alloy desired. It is indispensable that the copper added should be of equal quality to that in the 50 per cent. alloy. For this reason certain careful founders prepare this alloy with their own hands. When the fusion is complete and the mass at rest in the crucible, it is stirred with a bar enclosed in refractory clay, the surface skimmed and the copper added, or the oxidizable metals which complete the alloy. A stick of green wood is also used for stirring the molten metal, which is generally cast in shell to prevent its cooling on the sides of the mould. Unlike copper and nickel, the white metals are rolled cold. Maillechort requires several reheatings before it can be made into leaves. These reheatings require minute precautions, which it would take too long to enumerate here. . . The binary alloy, 20 per cent of nickel to 80 per cent of copper, prepared in suitable forms, may be rolled or stamped in the cold with a simple annealing without intermediate reheating. This is of all the white metals the one that has been most carefully studied on account of its applications in the manufacture of ball casings for the new arms of small calibre and great initial velocity. The adoption ef these arms necessitated the modification of the projectile, which would be destroyed or at least distorted in the barrel of the weapon if made of hardened lead as formerly. It was therefore necessary to cover the ball with a rigid case made of a metal sufficiently malleable to conform to the rifling of the barrel, and on the other hand capable of sustaining the explosion without being put out of shape. Lastly, it required an almost unoxidizable metal to secure the safekeeping of the ammunition. These several conditions appear to be realized in the alloy of 20 to 80 adopted by most of the nations of Europe for their new armament. . . An application indicated by the properties of this alloy is its use for locomotive fire boxes instead of copper. It is known that the great difficulty in the manufacture of these articles, besides the large size of the plates to be rolled (which reach usually 3½ metres), is the procuring of uniformly good surfaces, free from flaws, bubbles or other defects which, acting as centres of oxidation, shorten the life of the fire-box. The relative slowness of oxidation of the white metals gives them from this point of view great advantage. But these plates should be scraped with an engraver's tool during the rolling process in order to remedy the faults which may reveal themselves. . .

The manufacture of covers and silvered objects, called 'Roolz,' 'Alfenide' or 'Christophle,' from the names of the principal French houses which deal in this sort of ware, constitutes an important outlet for nickel. The principle is well known, namely that of covering electrolytically a stamped or moulded article with a layer of silver of greater or less thickness. At first the metal

An important outlet for nickel.

posit was made was brass, but its use has been rapidly aced by that of 'maillechort,' which has the advantage of w when use has removed the silver coating. In America hemselves for the most common uses with covers of white t all, but simply polished, which replace for the western vers of tin. Hundreds of tons of alloys are consumed rpose. The valley of Waterbury in Pennsylvania is the ifacture, favored as it is by the existence of numerous the grouping of a population accustomed for a long time nickel and white metals. This industrial centre is well ifacture of watch movements and cases of nickel or nickel which sell the world over.

Nickel money.

he uses of nickel one cannot pass over in silence that which garized this metal, namely, its employment, or more exactly , for small coins by a large number of countries, especially in place of copper. The majority of States which belong ion have not yet renounced the use of copper coinage, not- mitted inconvenience. Following is a list of the countries nickel money, and the date of the first issues in each: merica, 1853, 1864, 1869, 1871, etc.; Switzerland, 1858, 1889; Belgium, 1861, 1862, 1863; Costa Rica, 1867; Honduras, 1869, 1870; Jamaica, 1871; Brazil, 1871; n Empire, 1874, 1876, 1888; United States of Colombia, ; Venezuela, 1876, 1886; Mexico, 1882; Servia, 1883; lgaria, 1887; Romania, 1891; Argentine Republic, 1891. neral for 5, 10 or 20 centimes (or pfennigs). For the and Germany have struck pieces of pure nickel, which is nterfeit and less subject to wear. They replaced pieces under in silver which circulated with difficulty. The adopted a type of five cents, of which coins a certain every year in view of the growing needs of the popula-

o enters at some length into the question of the alloys of d steel, referring to the experiments of Riley at Glasgow, nickel steel armor plate for war vessels by the Navy Depart- l States. Riley's experiments have already been published Royal Commission on the Mineral Resources of Ontario ails of the U. S. Navy Department tests are referred to eport, *ante*, pp. 136 8. He goes on to say:

PRODUCTION OF NICKEL.

Increase of demand for the metal.

of nickel remained almost stationary until the opening up ew Caledonia in 1878. It was at that time about 400 world. This figure increased in 1880 to 1,200 tons and to In 1886 the application of nickel to military purposes e demand for this use alone of 400 or 500 tons per year, account the normal increase of consumption due to the applications already known, so that in 1887 the annual e world may be placed at about 3,000 tons of pure nickel. ew World and the extreme East consumed about one-fifth, g used in Europe. At that period New Caledonia was almost e production, and produced about 2600 tons of nickel yearly. es of Canada, scarcely known in 1888, have undergone a They are not hindered in that country by the difficulties d transport which impede the work in New Caledonia, as een. The district of Sudbury, with three or four large

Capacity of production of Ontario and NewCaledonia nickel.

furnaces in operation, is now in a position to produce a daily output of 12 or 15 tons of nickel contained in a cupro-nickeliferous matte, or about 4,500 or 5,000 tons per year. New Caledonia under existing circumstances is capable of a similar production, so that we may conclude that in a short time the total annual production of these two countries will be from 9,000 to 10,000 tons of pure nickel yearly.

Fluctuations of price.

The price of nickel has naturally fluctuated during the period when the new sources of production were being opened. In 1876 a kilogram of refined nickel was valued at about 18 francs. It fell a little later very rapidly to 10 francs, then to 6 francs, at which price it remained for some time. Since 1886 the metal has been more steady in its value, varying between 5.50 and 5 francs, depending upon the magnitude of the transaction. It is probable that the value, looking at the actual provisions for new outlets, will remain for some time at about this quotation. These prices are for the pure nickel refined, because one can deliver nickel either alloyed with the copper of Canada or under the form of the pig iron of New Caledonia at a much lower price, since the great part of the cost of refining will thus be avoided, if it were found possible to utilize to advantage the nickel in these intermediate forms.

IX.

CONSTITUTION OF NICKELIFEROUS PYRRHOTITE.[1]

By Dr. Stephen H. Emmens, President of the Emmens Metal Company, Youngwood, Pennsylvania.

The theory of replacement.

It is the custom of mineralogists to speak of many mineral varieties as formed by one metal "replacing" another to a greater or less extent in certain chemical combinations. This is, I think I may say, the invariable account given in the text-books respecting nickeliferous pyrrhotite, a mineral described as consisting of an iron sulphide in which "part of the iron is replaced by nickel." The object of the present paper is to enquire whether the account in question is a correct representation of the facts of the case, or whether the constitution of nickeliferous pyrrhotite differs from the description given in the text-books.

Formula of pyrrhotite.

The general formula of pyrrhocite is $Fe_n\ S_{n+1}$. This is sometimes written n (Fe S). $Fe\ S_2$ or n (Fe S). $Fe_2\ S_3$; though probably, for reasons analogous to those recently set forth (Journal of Analytical and Applied Chemistry, vol. VI. No. 10, October, 1892), the more correct view is to regard the typical compound, $Fe_3\ S_4$ as being a homogeneous body, and not as being composed of a mixture of sulphides. This question however is comparatively unimportant in the present discussion; as, whatever may be the precise arrangement of the molecules, their number will not be changed, and pyrrhotite will still be defined as an iron sulphide composed of n molecules of Fe and $n + 1$ molecules of S. And, on the "replacement" theory, nickeliferous pyrrhotite will be a sulphide composed of x molecules of Ni, $n-x$ molecules of Fe and $n+1$ molecules of S. Let us test this numerical theory by the actual results of analysis.

Analyses.

At p. 74 of the 6th edition of Dana's Mineralogy is a table of analyses of various specimens of pyrrhotite. From this I will select the following for discussion, namely:

		S.	Fe.	Ni.
No. 14.	Brewster, N.Y	37.98	61.84	0.25=100.07
" 15.	Putnam Co., N.Y	39.28	60.03	0.78=100.09
" 15a.	" "	38.99	60.04	1.02=100.05
" 15b.	" "	39.85	58.73	1.53=100.11
" 20.	Frigido	39.65	58.18	2.17=100.
" 18.	Hilsen	40.27	56.57	3.16=100.
" 17.	Sudbury	38.91	56.39	4.66= 99.96
" 19.	Gap Mine, Pa	38.59	55.82	5.59=100.

Demonstration.

Now it is obvious that any replacement of iron by nickel must take place by whole molecules weighing respectively 58.6 for Ni and 55.9 for Fe. Hence for every Ni molecule in mineral No. 14 of the above list there must be $(58.6 \div .25) \times (61.84 \div 55.9) = 259.3$ molecules of Fe; and, in like manner, there must also be $(58.6 \div .25) \times (37.98 \div 32) = 278.2$ molecules of S; or, in view of the analytical total being a little in excess of 100, we may regard the mineral as consisting of $Ni\ Fe_{259}\ S_{278}$ instead of $Ni\ Fe_{259}\ S_{261}$, as called for by the pyrrohtite theory.

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[1] Reproduced by permission of the writer from the Journal of the American Chemical Society, vol. XIV. No. 10.

Similar calculations in the other cases give the following results :

No. 15............. $Ni\ Fe_{80.68}\ S_{92.22}$ showing an excess of $S_{9.54}$

" 15a...... ..... $Ni\ Fe_{61.71}\ S_{70.00}$ " " $S_{6.29}$

" 15b .... $Ni\ Fe_{40.24}\ S_{47.69}$ " " $S_{5.45}$

" 20.............. $Ni\ Fe_{28.11}\ S_{33.46}$ " " $S_{3.35}$

" 18.............. $Ni\ Fe_{18.77}\ S_{23.34}$ " " $S_{2.57}$

" 17..... .... $Ni\ Fe_{12.685}\ S_{15.29}$ " " $S_{0.605}$

" 19.............. $Ni\ Fe_{10.468}\ S_{12.642}$ " " $S_{0.174}$

In none of these minerals does the formula $(Fe\,Ni)_n\,S_{n+1}$ hold good ; and we therefore have reasonable ground for declaring that the constitution of nickeliferous pyrrhotite is *not* represented by this time-honored but somewhat superficial generalization.

Relation of sulphur to nickel in pyrrhotite.

It will be noticed that the excess of sulphur bears some relation to the percentage of nickel ; the lower the nickel contents the greater being the surplus of sulphur, and vice versa. This necessarily follows from the great size of the compound molecule when the percentage of nickel is small. If however we investigate the proportion borne by the sulphur to the total metal, we shall find a tendency to constancy rather than to variation, as is shown in the following table :

Percentage of nickel.	Proportion of S Molecules in Excess of $n+1$ to		
	Ni Molecules.	Fe Molecules.	Ni+Fe Molecules.
0.25	16.9	.0652	.0649
0.78	9.54	.1182	.1168
1.02	6.29	.1019	.1003
1.53	5.45	.1354	.1322
2.17	3.35	.1192	.1151
3.16	2.57	.1369	.1300
4.66	0.605	.0477	.04421
5.59	0.174	.0166	.01517

This suggests that the constitution of nickeliferous pyrrhotite is polymeric ; an inference which is also supported by the fact that Nos. 17 and 19, containing the high nickel percentages of 4.66 and 5 59, show less than 1 complete molecule of sulphur in excess, and therefore require a multiplication of their several figures. Taken as a whole however the results of analysis are opposed to any assumption of homogeneity of structure.

Physical investigation.

Coming now to physical investigation, we are at once met by a feature that is conclusive against the hypotheses of " replacement " and homogeneity. I allude to the fact that nickeliferous pyrrhotite may be divided into two portions, one of which is magnetic while the other is non-magnetic. This fact has long been known to chemists. In 1879 Habermehl effected a separation of the magnetic from the non-magnetic portions of pyrrhotite for the purpose of obtaining a pure mineral for analysis. In 1890 T. J. McTighe applied magnetic separation in the treatment of the nickeliferous pyrrhotite of Canada ; and in July of this year T. A. Edison applied for a U. S. patent, in respect of virtually the same invention, and filed a specification containing the following statement :

Treatment by magnetic separation.

Edison's "discovery."

red that where magnetic pyrites, called 'pyrrhotite,' is usually is to a more or less extent, the nickel is not dis- throughout the whole body of the pyrrhotite, but certain yrrhotite or magnetic pyrites, while other crystals have placed by nickel and sometimes by cobalt, and that the the nickel or cobalt are considerably less magnetic than "

nade by Mr Edison is deserving of respectful attention ; gentleman has frequently disclaimed anything beyond a edge of chemistry and is therefore presumably open to s belonging to that department of science. Be this how- am safe in saying that pyrrhotite is rarely found in a l that crystals of nickeliferous pyrrhotite are as yet unre- een observed. Mr. Edison's mention of "crystals" is se way of describing the minute fragments, particles or e massive pyrrhotite is divided by comminution.

son speaks of the strongly-magnetic particles as being meaning thereby a non-nickeliferous iron sulphide of the +1. My own observations do not confirm the statement rrhotite can be magnetically separated into nickeliferous s portions. A separation into two very distinct minerals is possible, and these contain very distinct percentages are nickeliferous. The following results obtained by Mr. aboratory of the Emmens Metal Company will illustrate

Separation into two distinct nickeliferous minerals.

nickeliferous pyrrhotite were taken, one from the Gap , Pa., and the other from a mine near Sudbury, Ontario. ly powdered and then each sample was carefully separated gnet into three grades, namely, "magnetic," "feebly on-magnetic." The "magnetic" and "non-magnetic" alyzed and resulted as follows, after deduction of gangue :

Results obtained from Gap and Sudbury ores.

	Ni.	Fe.	S.
....	0.35°/。	59.97°/。	39.68°/。
tic	15.59 "	43.00 "	41.41 "
ic	1.30 "	58.27 "	40.43 "
agnetic..	23.16 "	33.92 "	42.92 "

gures in the same way as those of the analyses recorded

1. Molecular Constitution—

ic......... $\mathrm{Ni}\quad \mathrm{Fe}_{46.99}\quad \mathrm{S}_{56.95}$ showing an excess of $\mathrm{S}_{7.96}$
agnetic .. $\mathrm{Ni}\quad \mathrm{Fe}_{1.535}\quad \mathrm{S}_{3.394}$ " a deficiency of $\mathrm{S}_{0.141}$
.... $\mathrm{Ni}\quad \mathrm{Fe}_{179.6}\quad \mathrm{S}_{207.6}$ " an excess of $\mathrm{S}_{26.}$
tic......... $\mathrm{Ni}\quad \mathrm{Fe}_{2.891}\quad \mathrm{S}_{4.864}$ " a deficiency of $\mathrm{S}_{0.027}$

. Proportion of Excess S to Metal—

Proportion of S molecules in excess of $n+1$ to

Ni molecules.	Fe molecules.	Ni+Fe molecules.
26.00	.1448	.1440
7.96	.1694	.1659
Slight deficiency of S.		
"	"	"

the results here obtained with those from Dana shows magnetic minerals are of the pyrrhotite type, but that centrates are of a quite dissimilar constitution ; and as higher in nickel than the former it is also clear that the as an element replacing iron in pyrrhotite. It is also apparent that the minerals Nos. 17 and 19 of Dana are mixtures of the magnetic and non-magnetic minerals found in the Gap and Sudbury samples examined by Mr. Mixer.

Much additional investigation is needed to determine the true constitution of pyrrhotite and its allied nickel compound. It may be that experiments as to the solvent action of molten ferrous sulphide upon iron disulphide and nickel sulphide will throw the needed light upon the subject. Many geologists are of opinion that the massive pyrrhotites of Canada and other places are the cooled remains of a molten mass ; and every parcel of matte produced from a smelter is an object lesson respecting the varying mixtures that are possible under such conditions. Provisionally therefore we may regard the constitution of the minerals under discussion as represented by the following formulæ :

Crystalline pyrrhotite................	$n\ (Fe_3\ S_4)$
Amorphous do	$n\ (FeS).\ x\ (FeS_2)$
Nickeliferous do	$n\ (FeS.\ x\ FeS_2)\ y\ (NiS)$.

The practical problem of magnetic concentration.

In conclusion it may be well to say a word as to the practical problem of the magnetic concentration of nickeliferous pyrrhotite. The two samples above referred to as examined by Mr. Mixer gave the following results :

1. Division of the total sample :

	Gap.	Sudbury.
Magnetic portion	58.66 per cent.	92.95 per cent.
Feebly magnetic portion..........	6.67	2.09
Non " "	34.67	4.96

2. Division of the total nickel contents :

Magnetic portion	16 25 per cent.	58.01 per cent.
Feebly magnetic portion..........	19.96	7.60
Non " "	63.79	34.39

3. Total gangue in sample :

Gap	41.28 per cent.
Sudbury	10.7

4. Division of the total gangue :

Magnetic portion	25.85 per cent.	75.51 per cent.
Feebly magnetic portion...	7.12	9.07
Non " "	67.03	15 42

5. Percentages of gangue in the portions :

Magnetic portion	18.20 per cent.	8.70 per cent.
Feebly magnetic portion..........	44.00	46.60
Non " "	79.80	33.20

The practical inferences from these figures are as follows :

1. Magnetic separation will give a rich nickel concentrate.
2. An ore with considerable gangue will yield more of its nickel as "concentrate" than will be the case with cleaner ore.
3. The concentrate from clean ore will be of a higher grade than that from ore carrying much gangue.
4. The nickeliferous portion of the mineral is attached to the gangue more firmly than is the non-nickeliferous portion.
5. The nickel is *possibly an essential constituent of the gangue instead of being a constituent of the pyrrhotite.*

This last inference is so opposed to the generally-received teachings that I have instituted a fresh series of investigations with a view to determine its correctness or the reverse. The results shall in due course be communicated to the Society ; and, in the meantime, all I can say is that at present they seem to favor the supposition of the gangue being nickeliferous.[2]

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[2] Writing to me under date of April 8 Dr. Emmens says :

"I think that sometime in the course of the present year we shall introduce into Canada the practice of magnetic concentration of nickel ores. We have negotiations pending with some Duluth parties in this direction.

"I am at present investigating the cobalt question and am having some remarkable experiences with the Drury matte. Cobalt appears to be present in quite unusual abundance, and I also find some manganese, together with a new substance which, if not a hitherto unknown allotropic modification of nickel or cobalt, is a new metal."

X.

SOME NEW NICKEL MIENRALS.[1]

By Dr. Stephen H. Emmens of Youngwood, Pennsylvania.

I have of late had occasion to examine numerous samples of ores from the recently developed mining region known as the Sudbury district in the Province of Ontario, Canada, and in the course of such examination I have met with three nickeliferous minerals that appear to be distinct from any species hitherto described.

FOLGERITE.

This is found in the Worthington mine, on the Algoma branch of the Canadian Pacific railroad, about 30 miles southwest of Sudbury. The mineral deposit here opened up is of a character similar to that usually observed in the mines of the district; that is to say, it consists of a mixture of pyrrhotite and chalcopyrite, forming ore masses of approximately lenticular form and of varying magnitude, imbeded in a green stone dyke traversing the Huronian rocks that constitute the chief geological features of the region.

The pyrrhotite is in itself nickeliferous to a greater or less degree in every mine of the district, but at the Worthington mine it is found to be associated with a distinct sulphide (folgerite) carrying a very high percentage of nickel. This sulphide is spoken of by the local miners and newspapers as being millerite, but it differs widely from that species. Its chief characteristics are as follows:

Characteristics of the mineral.

Lustre: Metallic.

Color: Light bronze-yellow in mass, but almost tin-white when broken up into fine grains.

Specific gravity: No determination of the pure mineral has been made, but a fragment associated with adhering pyrrhotite showed a sp. gr. of 4.73.

Hardness: 3 5.

Streak: Grayish black.

Form: Massive with a platy structure. No crystals have as yet been observed.

Fracture irregular: When comminuted the large fragments preserve a platy form while the smaller particles are finely granular. Very brittle.

Heat reaction: When the powdered mineral is heated in a closed tube no sublimate is produced.

Solubility: The mineral dissolves in nitric acid with separation of sulphur and a green solution.

Magnetism: In large fragments the mineral is non-magnetic. In minute grains it is magnetic. The finely triturated powder is non-magnetic.

Microscopic appearances: Under both lens and microscope the powdered mineral appears in the form of shining white grains of irregular form, very distinct from the shining spicules of a light brass-yellow color which constitute the powder of true millerite.

Chemical analysis: The specimens analysed were magnetically separated from the accompanying pyrrhotite and gave the following results:

Analyses.

	A.	B.	C.
Nickel	35.20	31.45	29.78
Iron	33.70	31.01	26.89
Sulphur	31.10	37.54	43.33
	100.00	100.00	100.00

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[1] Reprinted with permission of the author from the journal of the American Chemical Society, vol. XIV. No. 7.

Locality of the mineral.

Specimen A consisted of platy fragments, each one of which was tested separately with the magnet. Specimens B and C were separated in the form of a coarse powder from the accompanying pyrrhotite, and probably still contained some adhering particles of that mineral. In the cases of B and C the analysis was conducted by first roasting the mineral and then fusing with potassium bisulphate, followed by solution, peroxidation, precipitation of the iron and electrolytic separation of the nickel, all with the usual precautions. In the case of A the raw mineral was dissolved in aqua regia. The sulphur was estimated by difference; and a check determination (by fusion of the raw mineral with sodium carbonate and nitrate and final precipitation as barium sulphate) for sulphur only, in a fourth sample, gave 34 per cent It may also be mentioned that specimen A came from the Worthington mine, and that B and C were sent to me with the statement that they came from a deposit at the northeast extremity of the Worthington greenstone dyke. This deposit is distant about 1½ miles from the Worthington mine and has recently been explored by the Emmens Metal Company; but when Mr. C. T. Mixer, the chemist of that company, paid a visit of inspection to the workings, the person in charge who had sent me the specimens in question could not point out the place whence he had taken them, and could not show any further occurrence of the mineral *in situ*. It is probable therefore that A, B and C all came from the Worthington mine.

The formula corresponding with the above mentioned analysis is $NiFeS_2$, which corresponds to

Nickel	32.87
Iron	31.30
Sulphur	35.83
	100.00

This composition is between NiS (millerite) and $NiFe_2S_3$ (pentlandite). It is also distinct from that of the "ferriferous polydymite" found at the Vermilion mine, a little to the northeast of the Emmens Company's working, and described by Clarke & Catlett (American Journal of Science, 1889, p. 372), as containing 43.18 per cent. of nickel, 15.47 per cent. of iron and 41.35 per cent of sulphur, and as approximating therefore to the formula Ni_3FeS_5.

I have named this mineral folgerite after Commodore W. M. Folger, the Chief of the Bureau of Ordnance in the U. S. Navy Department, in recognition of that distinguished officer's achievements in the utilization of nickel steel.

BLUEITE.

Localities of the mineral.

This mineral has for some time past puzzled the Sudbury miners, who have locally dubbed it "Jack's Tin." It is found in several mines of that district and notably at the working of the Emmens Metal Company, where it is found associated with niccolite, gersdorffite, pyrrhotite and chalcopyrite in the outcrop of a quartz vein cutting the before-mentioned greenstone dyke.

Characteristics.

The following are the characteristics of the mineral:

Lustre: Metallic, somewhat silky.

Color: Pale olive-gray, inclining to bronze.

Specific gravity: 4.2.

Hardness: 3 to 3.5.

Streak: Black.

Form massive: No crystals have as yet been observed.

Fracture: Sub-conchoidal, irregular. Brittle.

Heat reaction: When the powdered mineral is heated in a closed tube a sublimate of sulphur is produced.

Solubility: The mineral dissolves readily in nitric acid without separation of sulphur and yields a yellow solution.

Magnetism: The mineral is non-magnetic.

Microscopic appearance: Under the lens the powdered mineral appears to be composed of irregular grains of a dull gray color. Under the microscope the color appears a dull grayish black and the particles are seen to be finely granular without any crystalline form.

Chemical analysis:

Nickel	3.5
Iron	38.8
Sulphur (by difference)	52.3
Insoluble	5.4
	100.00

After deduction of the insoluble matter (gangue) the figures for the mineral become

Nickel	3.70
Iron	41.01
Sulphur	55.29
	100.00

The sulphur is probably too high, as owing to the character of the gangue a portion of this latter may have entered into solution.

Formula.

The formula $Fe_{12}NiS_{26} = (Fe, Ni)S_2$ where $Fe : Ni = 12 : 1$) corresponds with the foregoing analysis, the figures of such formula being:

Nickel	3.76
Iron	42.96
Sulphur	53.28
	100.00

The considerable percentage of nickel (a very rare element in pyrite) and the easy solubility in nitric acid without separation of sulphur seem to preclude this mineral from being considered merely as a nickeliferous variety of pyrite or marcasite. I have named it blueite, after Mr. Archibald Blue, late Secretary of the Royal Commission appointed to investigate the Mineral Resources of Ontario, and now Director of the Bureau of Mines of that Province.

WHARTONITE.

Locality and characteristics.

This mineral was brought to me by Mr. C. T. Mixer from a mine situated about seven miles northeast of Sudbury and about two miles from the Blezard mine, worked by the Dominion Mineral Company. It has been known locally as the Shepherd mine, and is of a character similar to the general mines of the district.

The following are the characteristics of the mineral:

Lustre: Metallic.

Color: Bronze-yellow.

Streak: Black.

Form: Cellular; the cavities being lined with minute cubic crystals and the intermediate substance being finely granular. This structure precludes the specific gravity and hardness from being determined with precision. A large piece showed a sp. gr. of 3.73 and a hardness of 4.

Fracture, irregular: Brittle.

Heat reactions: A sublimate of sulphur in a closed tube and fumes of SO_2 in an open tube. A sulphur flame is observed on heating a fragment held in forceps.

Solubility: The mineral is soluble in HNO_3 with separation of sulphur and a greenish yellow solution.

Magnetism: On comminution about 10 per cent. of the mineral is found to be magnetic.

Microscopic appearance: Under both lens and microscope the powdered mineral is seen to consist of grayish black grains of irregular form and finely granular structure, with occasional minute cubic crystals.

Chemical analysis :

Nickel	5.40
Iron	42 90
Sulphur	45.00
Insoluble	4.80
	98.10

After deduction of the gangue these figures give :

Nickel	5.79
Iron	45.98
Sulphur	48.23
	100.00

Magnetic and non-magnetic constituents.

Separate determinations of iron and sulphur were made in the magnetic and non-magnetic constituents respectively with the following results :

	Mag.	Non-Mag.	
Iron	66.55	40.4	plus a little gangue ;
Sulphur	7.00	52.6	

and a qualitative examination showed that the nickel was clearly with the non-magnetic portion.

The inference deducible from these observations is that the mineral is a mixture of a nickel-iron-disulphide with some magnetite ; and taking the proportion of this latter as being 10 per cent. we have for the composition of the other constituent :

Nickel	6.27
Iron	41.44
Sulphur	52.29
	100.00

Formula.

This corresponds to the formula $Fe_7 Ni S_{16}$ or $(Fe, Ni) S_2$, in which $Fe : Ni = 7 : 1$, and of which the figures are :

Nickel	6.10
Iron	40.68
Sulphur	53.22
	100.00

It may be that this non-magnetic mineral is in part composed of pyrite, in which case the formula will require modification. The aggregate however is distinguished by its form and nickeliferous character from pyrite and marcasite.

I have named this mineral whartonite after Mr. Joseph Wharton of Camden, N.J., in recognition of that gentleman's eminence as the head of the nickel industry in America.

NICKEL AND NICKEL-IRON SULPHIDES IN GENERAL.

Relations of nickel and nickel-iron sulphides.

For the purpose of indicating the relations of all the known nickel and nickel-iron sulphides to each other, the following table may be found useful :

Name.	Percentage constitution.			Molecular constitution.			
	Ni.	Fe.	S.	Ni S.	Ni S_2.	Fe S.	Fe S_2.
Millerite	64.72	....	35.28	1	......	......	.. ...
Polydymite	59.47	....	40.53	3	1	......	......
Beyrichite	57.90	....	42.10	2	1	......	......
Ferriferous polydymite	44.92	14.26	40.82	3	......	....	1
Folgerite	32.87	31.30	35.83	1	.. ...	1	......
Pentlandite	22.03	41.95	36.02	1	......	2	......
Horbachite	11.24	42.81	45.95	1	1	1	1
Inverarite	10.44	49.72	39.84	1	.. ..	4	1
Whartonite	6.10	40.68	53.22	.....	1	......	7
Blueite	3.76	42.96	53.28	......	1	......	12

It remains to be added that the analyses of the new minerals herein described were made by Mr. C. T. Mixer, and that specimens of folgerite, blueite and whartonite accompany this paper for exhibition to the meeting.

XI.

A PIONEER'S MINING EXPERIENCE ON LAKE SUPERIOR AND LAKE HURON.[1]

By Walter William Palmer, Washington, D.C.

From Quebec to the Sault.

Agassiz and Jackson.

On landing at Quebec from England June 1st, 1848, and presenting letters, Mr. Bonner engaged me to proceed to Mica Bay on the east shore of lake Superior as surveyor to the Quebec Mining Co., and otherwise to assist Mr. Oliver Matthews the mining manager there at £100 per annum, Halifax currency, besides rations and suitable quarters. I wended my way via Montreal, Toronto and Windsor through red hot Canadian politics, and at the Sault found a delightful change in the association for a few days with Prof. Agassiz and a party of Cambridge students awaiting outfit to investigate the zoology of the north shore, and Dr. Charles Jackson and his assistants on their way to prosecute the geological survey of the south shore of lake Superior. Entertainment was found by inspecting the three and four ton masses of native copper from the Cliff mine, awaiting on the wharf for reshipment, and occasional familiar discourses by the professor on natural history and the glacial theory, and by Dr. Jackson on the igneous origin of the native copper of the south shore of lake Superior from its source in the sulphides on the north shore of lake Huron.

MINING ON MICA BAY.

Settling down to duties.

As soon as Prof. Agassiz and his party were despatched Mr. Peter Barboux turned his attention to me and the six miners for Mica Bay, and in due time we were on the way in a bateau and a canoe in charge of Charles Rousseau and a few Indians. We overtook the professor at his camp at Gros Cap, and found that he and his fresh blooded young men had been very attractive to the black flies and mosquitoes. As we made the traverse of Batchawana bay, and they went around it deliberately, they did not appear at Mica Bay until I had some glacial striae to show the professor on his arrival, and had settled down to my duties of seeing the written orders of Mr. Matthews properly executed. My spare time was filled in exploring the location and making a geological map of the same, and keeping up the new working plan of the mine, which employed about forty miners and was under the excellent foremanship of Mr. Joseph Rodda. The surface operations and fifty men were in charge of Mr. Clarke.

Laying in a store of provisions.

Along in the fall our 11-ton sloop, the Sisquette, brought from the Sault John Bonner, the secretary of the company, and his son Charles, a lad of about 11 years, to spend the winter with us; also Mr. David Price of Chili to establish the Chilian method of making copper regulus (by wood).

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[1] WASHINGTON, D.C., 2000 R. street, 23rd Feb., 1893.

To Archibald Blue, Esq., Director of the Bureau of Mines for the Province of Ontario:

DEAR SIR,—I have the honor to enclose you a few notes as far as my memory serves me of my mining experience in Canada on the lakes Superior and Huron, the mines there located being then considered the most important in Canada. With good wishes for the progress of the industry, I remain very truly yours, WALT. WM. PALMER.

Mr. Palmer spent a portion of the past winter in Toronto with members of his family. He called upon me frequently and I persuaded him to furnish for the Report of the Bureau some account of his experiences in the copper mines of Ontario during a period now well-nigh forgotten. In this way the interesting paper which follows had its origin. Mr. Palmer is a native of Devon, England, and received an education there to qualify him for a mining engineer; and since leaving Canada, more than forty years ago, he has been devoting his life successfully to that profession in the United States and Mexico.—A. B.

The sloop was well freighted with provisions, luxuries, medicines, wines and spirits, and various barrels of beer for the hypothetical smelters. John Thompson Newton, the medical man, and Mr. Duffett the storekeeper had previously arrived.

A sad episode.

The sloop returned immediately to the Sault to meet the bulk of the winter's provisions, which had been sent later by the propellor from Detroit, but after waiting a sufficient length of time she returned with only a remnant of previous freight and a French Canadian family which had been left at the Sault, and a letter from Mr. Peter Barboux containing the suspicions that the propellor had been lost. The weather was so rough that the sloop had to put into Mamainse harbor with the perishing family, whence a man arrived tattered and torn with the information. A volunteer crew were soon with a fair wind at Mamainse, but we could not return until late next day. A few crackers supplied to the children were meantime all the refreshments at hand. The father, mother and four children died within a few days after they were landed at Mica Bay; the remaining boy, about 11 years of age, was adopted by Mr. Bonner.

On the Sunday that we buried the parents on a knoll at the head of the village it was bitterly cold and tranquil, and a dark brown pall of evaporization about two fathoms high apparently and close upon the water overlaid the mighty lake. Thence all was clear to the clear and cloudless sky covering the solemn scene.

In hopes that Mr. C. C. Trowbridge had duplicated the order for provisions, late as it was in the season, the sloop was at once dispatched again to the Sault, Mr. Bonner consenting to my joining so that in case of no provisions of ours being there I might scour the Sault for a cargo. We did find the duplicate supply and took all we could of it, worked our way up the river and in the snow and storm espied just before dark Parisian island, and with a heavy and fair wind at dawn the next morning were close by and heading between Mamainse Point and the rock outside. The discharge of an old Hudson bay wall gun brought Clarke and his crew with a whale boat, who took me on board, and the sloop was sent into Mamainse for the winter.[2]

Supplementing the winter's scant store of provisions.

A few days later Mr. Clarke, who was from the Hebrides and had been many years in the Hudson Bay Co's service, full of resources, invited me to join him and his crew of French Canadians to visit an Indian encampment at the mouth of the Montreal river. Taking the necessary salt we sailed up 12 or 14 miles and in a few days scooped out of the mouth of the river a dozen barrels of lake trout; these with about forty visits during the winter to the same and other Indians, with cariboo and other game in exchange for stuff out of the store, supplemented our scant winter's supply of provisions, and with close economy not only carried through 110 souls but also, with the aid of the salt fish and spruce boughs, a cow and a pony. In the spring however some half dozen men were laid up with the scurvy and required medical attention.

The work proceeded with as much earnestness, order, dignity and Sabbath observance as if we had under hand an incipient Calumet and Hecla. Birthdays were celebrated, especially my majority on December 27th, 1848.

Pioneer work on the location.

On my first arrival at Mica Bay, Mr. Matthews had already brought daylight on the surface of the front of the location by an avenue cut south from the head of the village to the lake shore; by a road to the mine about half a mile north; by another avenue felled on the course of the vein west to the lake shore, passing down hill over the two old lake beaches shown by me to Prof. Agassiz and referred to in his treatise on the Zoology of lake Superior. These beaches with the debris frustrated the object that Mr. Matthews had of exposing the back of the vein, which could not be seen until reaching the trappean sandstone of the wash of the beach, and there the vein was seen only obscurely. Soon after Mr. Matthews caused the felling of another avenue, perhaps a half a mile north of the mine, to a brook which debouched into the lake at a greater distance west, laying say four miles of the sinuous coast-line all come-atable from one point to another and surveyable from the interior.

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[2] Mamainse harbor is about six miles south of the open roadstead of Mica Bay.

Exploiting for copper ore by adit and shaft;

The rock in place exposed itself immediately above and emerging from the upper beach gradually ascending in hogback form towards the interior of the location. At an altitude of say 180 feet above the lake and a quarter of a mile from it, an exposure of gray copper sulphide invited exploitation by adit. This work commenced in trap sandstone and continued into sandstone trap (a transition rock), both reddish and rottenish, but periodically strewn with enough of those carrot-shaped and carrot-sized gray sulphides to induce continuance of the work, but at the same time not producing ore enough to pay half the cost of the candle bill. In due time a shaft had to be sunk to give ventilation to the adit, and in the progress of this work the same kind of ore was found. Sinks in the bottom of the adit to depths attainable by windlass also responded in the same unsatisfactory way to all efforts to find the ore in reasonable body, and up to the date of my leaving, on 1st June, 1849, a few bucketsful only had been saved from meantime findings.

but with a sorry showing.

Mr. Palmer returns to Quebec.

On the conclusion of my year's engagement with the company Mr. Matthews at my request kindly furnished me with a boat's crew to take me to the Sault, and in due time, having examined the Bruce on the way down, I presented myself to Mr. Bonner in Quebec, who thoroughly rated me for leaving Mica Bay and abandoning my future prospects. He stated that he had induced the directors since he had been down to increase my salary; also that he had shown my maps to Lord Elgin, who had been pleased to say that they gave him his first idea of a mine, and that his lordship had invited him to dinner, for which dinner he was indebted to me. After chiding me again he invited me to dine with him, which I did at his house on the Plains of Abraham, and with sincere regret I bade this good gentleman goodbye.

Prince's Bay location.

On this visit to Quebec in June, 1849, I met Mr. John Tregoning and some of his men on their way to England, after having spent the preceding winter in the exploitation of the Prince's Bay location, near Fort William. They had with them to show their company in England some beautiful specimens of netted plate work of native silver enclosing crystals of calc spar; but I was given to understand by Mr. Tregoning, who was an invalid, that beyond such specimens occasionally met with nothing of substantial value had been found. They had also suffered from scarcity of provisions. At Mica Bay we had no suspicion that any mining establishment save our own was working on the north shore that winter.

Visitors at Mica Bay.

During the whole year the only visits of note that we received were two calls, one on his way up and one on his return, from Prof. Agassiz and his students; one from Hugh Wilson, an annexationist from Hamilton; and occasionally during the winter from Father Kohler, a missionary among the Indians; and in the spring from Mr. Ballentine, assistant manager of the Hudson Bay Co., on his way home invalided, via Vancouver; and Sir George Simpson with his fleet of canoes on his way to the Pacific.

Agassiz.

The visits of scientific interest were those of Prof. Agassiz, who recognized on the decomposing slates on the south horn of the bay[3] fine examples of glacial striae. Upon his being shown by me the two terraced beaches, 80 and 160 feet respectively above the present one, he declined to give an opinion as to whether the water had receded or the land risen. Fur-

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[3] The north horn is a felspathic promontory, Point aux Mines, on Bayfield's chart.

Michipicoten island.

ther he said that it was an open question, and was highly gratified with the specimens of current fish which we caused to be caught and preserved for him in whiskey, as well as with the results of his expedition since he left us on his way up the lake.

After its expulsion from Mica Bay the Quebec Mining Company turned its attention to Michipicoten and continued operations to the fall of 1853, when the writer met there Mr. Jehu Hitchins, an English expert from London, and with him a director of the company with a view to passing over the same to an English corporation. Failing this the writer caused it to be passed over to Mr. Chauncey Bush, the head of a New York company, who during the next two seasons spent considerable money in exploiting there for native copper and silver.

IN THE EMPLOY OF THE MONTREAL MINING CO.

Officers of the company at Bruce Mines.

After a month's vacation exploring for Edward Thomas Renaud, the seignior of Berthier, I was sent to take charge of the mining department of the Bruce at £225 Halifax currency and quarters, and found there Archibald H. Campbell, the general manager; H. C. Pilgrim, clerk and cashier; Samuel Sedden Walbank, medical man; John Greenfield, purchaser and distributor of all supplies; Captain Wm. Harris, in charge of the general body of surface hands; and Captain Simmons, in charge of the miners and his share of the mechanics. Mr. Davis with a corps of Welsh smelters and masons was building a full set of reverberatory furnaces, six in number. Engineers and mechanics were busy bringing to completion the engine house, crusher and jigging buildings and corresponding machinery. Captain Martin, the ore dresser, in charge of men and boys, was gleaning stray ores from early surface blasts, spalling and prilling and hand-jigging the smalls of the past and current product of the stopes preparatory to crushing and smelting. James Carson, afterwards a famous mining speculator, was building by contract at the south face of the bay a row of frame houses for the miners with families and another row at the west for the accommodation of the smelters.

Life at the Bruce.

The Bruce had steamboat communication and calls from all parts of the lakes, and was a busy place with upwards of six hundred men in active employment; and a pile of Cleveland coal was accumulating which at the close of navigation amounted, less consumption meantime, to five thousand tons; and soon Mr. Acton appeared as custom house officer. The water supply for all purposes was drawn directly from the lake, generally at the end of the plank resting on a stone in front of the respective houses; the wash of the hillside finding its way also into the same reservoir. Vegetable supplies came; potatoes, cabbage, cucumbers, etc., from distant parts; and chiefly from Major Raines, who had two homesteads on St Joseph's island four miles south. A Catholic chapel had been erected for the French, Irish and Germans, and soon after another sacred building was placed at the disposal of the various religious sects; and a minister and also a schoolmaster were provided by the company.

The departments in the hands of energetic men.

As my duties were confined to the superintendence of the mining operations and preparation of the ores for the smelting works, I cannot say anything about the other departments, save that they were all in the hands of energetic men, able and faithful. On requisition, Greenfield supplied material and Harris any extra men. The accounts were rendered to Pilgrim, who paid the pay-rolls, and periodic reports from all were rendered to the general manager, whose spare time was fully occupied in the assay office.

The mine, and how it was worked.

Straight up northerly about a quarter of a mile from the wharf landing, the eastern stope of the mine was open to daylight, which, with a whim shaft 200 fathoms westerly from this point, formed the end limits of all that there existed of the Bruce mines proper.

e ground formed a serrated trench irregularly excavated ing from 15 to 30 feet in depth along the apex of a out 50 or 60 feet above the level of the lake.

e eastern half of the vein exposure and up to where the ' and split in two—the apparent main vein making a outh—were uninterrupted and generally connected ; but n half were interspaced by benches of poorer ground.

clean and from four to six feet apart, and in the deeper nclination southerly was discernible by the drag of the

he previous winter had persuaded Simmons, the mining the stopes, and with a large part of his force he had the gunnies above with refuse and capped the whole with ring bed found near the swamp north.

te and nearly equidistant shafts had been reared from the he three western ones had their collars raised to about ten nd for dumps, and were equipped with horse whims, the g been correspondingly raised and encased with circles of assive vein quartz free of ore. The two eastern shafts the reach of windlasses.

he system of underhand stoping which had been followed the first shot in the mine by Colonel Rankin and Captain in view of the coming demands of the smelting works had e continued, Simmons had everything in corresponding my arrival.

t was about 100 feet deep, and already comparatively s of calc spar, some with double terminations.

hafts looked fairly well and averaged at least two tons of w sulphide for each square fathom of vein. The two e each about 60 feet deep on the vein, or about 70 feet llars. The two eastern shafts were respectively about 40 heir windlasses. The stopes containing four of the shafts retches of the vein.

Extent of the workings and number of miners employed.

now all underground, consisted of about 70 picked men, ges but the majority on contract, all either sinking or stop- man being engaged in any dead work underground ; and two blacksmiths, whose task was to sharpen each 26 ls per day.

water in the mine, either by seepage or by subterranean

SETTLING A LABOR TROUBLE.

cipated the impending race between the producing capacity sher and concentrating works and the smelting parapher- them who had been hired in England at monthly wages asked to be placed on a footing with the others on contract. the duplicate contracts were put into the office stove, and discontent was allayed. The excessive store charges were remedied so far as they applied to the necessities of life, system of measuring the ground was established on the

An incipient unpleasantness settled.

he last down boat of the season called at the Bruce wharf e whole of the outfit of Mica Bay. Mr. Bonner explained nvaded and expelled by a horde of Sault half-breeds under gus McDonald and his friends. This visit enabled us to cholera so far as numbers could do it, and we increased the 100 men. The boat then with some difficulty relieved her-

How the Mica Bay venture ended.

self from the ice which had formed while she lay at the wharf, and proceeded to Penetanguishene with the remaining majority of men, women and children and their effects, to be taken care of in Quebec by the Quebec Mining Company.

how the Bruce came to acquire odd types of mining men,

Some of the men that Mr. Bonner left had from their boyhood been western hap-hazard lead miners, and had never been brought under any rules of contracts. They knew all that was then known on human rights and the dignity of labor, of which our men had never troubled themselves. On the other hand Greenfield had lately brought up 100 Germans from Detroit, and among them were many ex-statesmen and ex-college professors who were masters in social science, having graduated in the revolutions of '48. Many of these, with the supposed ex-minister of Wurtemburg at their head, were now engaged in wheeling coal and carrying the buckets of beer and assisting in drinking it with the Welsh smelters, whose liberal supply of beer and whiskey allowed them often during the day and night, in their streaming perspiration, to drink to the prosperity of the Montreal Mining Company.

and how the Captain's tact mastered the men on settling day.

Meantime the Mica Bay men had been good naturedly admittted and absorbed into the contracts, and had deliberately tested the quartz and complained that it was as hard as—well corundum. Whether it was the introduction and mixing a lot of men unacquainted with the ground, or whether it was the sight above them of a horizontal line of equidistant holes which made a square fathom of ground look larger than it ever looked before, was unknown; but soon after close of navigation the superintendent of the mine received some very neatly-written letters intimating that unless contract prices were raised dire personal consequences would be the penalty. The contracts were measured as usual without remark on either side, and on settling day Captain Simmons rang the bell as usual to call up the men. The only thing unusual on that day was that on invitation Mr. Campbell came to see the fine body of one hundred men.

The letters were read and their receipt acknowledged, but the settling of the contracts was suspended, pending the operation of a reward of £500 for the discovery of the writers.

The men made no remark and as quietly received the recommendation to keep the peace and to get from the store a winter's supply of provisions; but in less than a month a compromise was made by all of them taking the Scotch oath protesting innocence in the affair, and taking a contract to extend to the opening of navigation at a slightly reduced price per fathom. Thenceforth they worked during the whole winter in good earnest, and did well indeed in work and wages. Meantime the other departments were uninterrupted.

It is due to this fine body of men to say that they did not strike; that they did not destroy a particle of property; nor did I hear a disrespectful word. No one lost anything by this interruption. The company gained by the reduction in price, and the men gained at least 25 per cent. more wages by having a long stretch of a contract freed from the petty interruptions of monthly measurements. The sum and substance of the whole business was that on the 1st June, 1850, in addition to supplying the reduction works with current ore, Captain Simmons had a much larger accumulation of crude ore on the dump than he had when I arrived at the mine less than a year previously; and this though no improvement had taken place in the mine, and a few points had weakened considerably in depth.

ROLLS, JIGGS AND SMELTING WORKS.

Breaking and repairing the machinery.

The rolls passed the prills through comfortably, but soon corrugated badly on the second class ore, involving repeated passages of the ore and too frequent changes of the shells for the stock in hand of those necessary wearing parts. One night on stopping the engine to key on new shells the frost got into the crown wheel, and on starting up it broke into several pieces. The ntracted engine runners congratulated themselves that they had ahead a inter's holiday and a winter's pay, but this was frustrated by Henry Villiams and his comrade, two miners, under whose managament a new heel was moulded. They failed to fill the mould with cast iron from their nprovised blast furnace built in a hogshead; but next refining day Mr. avis was good enough to allow a half dozen men to ladle and fill the mould ith refined copper. The wheel weighed 700 pounds, and I was told it did uty for some years afterwards.

Jigging machines.

Captain Martin with his few jigging machines in the confined building for inter operations attached to the engine house could easily take care of all the rop of ore that the crusher sized, and as the vitrified furnace bottoms near y gave way at uncertain periods he had still less trouble in supplying Mr. avis with all the ore that he could turn into ingots.

A smelting works incident.

Up to May, 1850, the product of the smelting works had failed to respond the mine estimates or to the quantity of metal that the assays called for, nd the coal pile began to look small, so one day on visiting and inform- g him of these facts Mr. Davis ordered the furnaces drawn and all his hands leave the building, and I was left alone to lock the doors, which I did and ok the keys to Mr. Campbell. There was no defect in principle nor want f skill in the smelting works, which like the concentrating at first started in e face of winter when defects could not be corrected. Another season's ork would have brought a more energetic fuel and a more tenacious sand for e furnace bottoms.

WHY THE MINE FAILED.

The vein unbottomed by jasper conglomerate.

But as for the mine, no skill could avert the inevitable. On his visit to e mine in 1848 Mr. Logan had pointed out that the pudding-stone (jasper nglomerate) which bluffs two miles east would unbottom the vein at an verage depth of 250 feet, and the vein when he saw it was probably averag- g four tons per fathom. Now it is said that Sir William, then Mr. Logan, stimated the ore in sight at 35,000 tons. Probably his data was: The ore xposure at the mine, 216 fathoms; the average depth at which the pudding- tone bed would unbottom the vein, 250 feet; the average value of the exposed ce of the ore, four tons per fathom. These factors make nearly 35,000 tons. have not the least doubt that the ore face averaged when he saw it in 1848 our tons per fathom. These are the only data now attainable to enable us judge the rate of deterioration with descent. The Report of the Royal ommission, p. 378, says: "the Geological Survey volumes are silent on the nterprise." The concern was private property and the geologists observe orresponding proprieties. But is it reasonable to suppose that when Mr. ogan imparted to the officers at the mine his views on the unbottoming of e vein by this pudding-stone that the Directors of the Company would long emain ignorant of the skeleton? Again all testimony is silent, but from tatements of the oldest inhabitants[4] it appears the Bruce and Wellington losed themselves in 1876 by the tapping of a body of water which inundated e mines, and by caving formed a lake of several acres, the level of which about 25 feet above lake Huron. Mr. Wm. Plummer says "the deepest haft was 500 feet." It looks as if this tapped the same conglomerate bed hich at this depth had resolved itself into quick sand.

Closing Miscellaneous Notes.

Prohibition.

The general good order of the establishment at Bruce Mines was occasion- lly discredited by excesses which led to Mr. Greenfield's complying with rders to cut a hole in the ice and sink in the bay the stock of liquors. This nticipated remedy was however frustrated by outside parties from the Sault supplying the stuff at St. Joseph's island. Many men took a walk there on the ice and a few never returned alive, and as the lesser of two evils a responsible man was licensed to open a public house. Thenceforth social relations took the normal form of average communities.

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[4] Not in the Royal Commission evidence.

A general exodus,

About the 1st June, 1850, the Hon. James Ferrier with a mining man or two and some smelters arrived, but their progress on the wharf was obstructed by the exodus of nearly all the miners, all the Welsh smelters and many of the German ex statesmen with their effects—their pockets full of money and in a hurry to get off to the Sault by the same boat which brought him from Penetanguishene.

which the head of the mining department joins.

No curling dense black smoke from the proud stack of the smelting works piloted him into the bay, and the other operative works were in suspense pending the bidding adieu by the remaining fourth of the departing three-fourths. The officers were still intact, but when his wrath was cooled and he could proceed with deliberation he began by making short work of myself by passing all my troubles over to my successor, who soon vastly improved the concentrating works; for either he or his successor, Archelaus Tregoning, had the good fortune to exhume from below the smelting furnaces in every smelting grade an amount equal to 100 tons of fine copper. So I was told by officers who afterwards joined me on the south shore of lake Superior.

Personals.

About these days the writer had the pleasure of meeting Col. Sam. Jarvis, Hon. Wm. Robinson and Sir Casimir Gzowski, then the Government engineer making preliminary survey on the Canadian side; and also Jacob Houghton, a younger brother of the lamented first geologist of Michigan, surveying for the canal, which important work he soon after commenced and executed in the Potsdam sandstone on the American side of the Sault.

St. Joseph's island and its ancient fauna.

For the purposes of the Bruce Mines, Greenfield opened a limestone quarry on St. Joseph's island. It was profuse in a large breed of trilobites and vertebratæ consisting of fish, some of the latter as large as those of the present day found in the lake. This stone was used for the erection of the engine house and foundations for smelting works.

Rounding up the story.

A visit to the mines at Port Arthur in company with Messrs. Walbank and Pilgrim in 1875, and thence three visits to Silver Islet, a charter of Ambrose Cyrette's tug to the Little Pic, and a railroad passage through the formation of Sudbury in the Fall of 1890, round up all the writer knows about mining in Ontario.

XII.

NEW SOURCES OF PLATINUM.

r. Stephen H. Emmens of Youngwood, Pennsylvania.

f the recently published Census volume on Mineral Indus-
d States reference is made to the development of nickel-
mines in Canada, and it is remarked that "the impression
a small amount of platinum might also be obtained from
te, but this does not seem to have been the case."

Platiniferous ore in Denison township, Algoma.

exists in the Algoma mining district of Ontario has been
the discovery of sperrylite at the Vermilion mine on lot 6
ession in Denison township. This was found in the gossan
pyrite, respecting which Dr. Robert Bell reports: "The
rite and is about four feet wide, but without distinct walls
xcept a mixture of the country-rock."

led me to pay special attention to some mining work that
the summer of 1892 by the Emmens Metal Company at the
on lot 12 of the third concession of Denison. This mine
of the eruptive dykes that characterize the district, and is
Messrs. Ricketts and Banks who inspected the property in

of the greenstone dyke has been stripped at several places
nd an inclined shaft sunk 37 feet at an angle of about 45°
upon a mineral vein in the diorite near the southeast con-
which latter, having a steeper dip southeast, is cut diagonally
ore lens has a nearly parallel trend to that of the dyke.
of ore at the collar of the shaft is about 6 inches thick; it
3 inches at a depth of 20 feet, and then gradually thickens
he shaft, where on the southwest side it is 13 inches thick.
largely a changed diorite, with some little quartz and fel-
eral irregular seams and scattered bunches of chalcopyrite
ith admixture of nickel minerals. In the bottom of the
heast side, the seam has pinched to about an inch, carrying
ets. In the hanging wall of the shaft in this locality
of sulphurets are exposed. The ore seam where thin has
ling, with thin seams of quartz and scattered sulphurets."

Analyses of specimens.

vein matter were sent to me from time to time, and upon
me to the conclusion that some of the mineral was platini
gly in July, 1892, I selected two specimens, one broken
m in the mineral and the other from the graphitic schistose
Messrs. Ricketts and Banks term "a shaly dioritic filling,"
f them to Mr. F. P. Dewey of Washington with instruc-
them for platinum, gold and silver. The following are
vey's certificates of assay:

rtz, etc.	
l	slightest trace.
r	0.73 oz. per ton.
inum	trace.
phitic schist.	
l	slightest trace.
r	1.1 oz. per ton.
inum	0.53 oz. per ton.

membered that these assays were made without any concen-
or separation of gangue. As therefore the sample of gra-

phitic schist sent for examination was a large piece, weighing nearly a pound, with very little show of sulphurets or other perceptible ore-matter, it seems almost certain that the concentrates from the same would furnish a platinum ore of commercial percentage. I did not however pursue the matter any further, because the working of the mine was abandoned on receipt of the report of Messrs. Ricketts and Banks who, having examined the property simply as a nickel mine, did not discover the occurrence of platinum.

The Canadian Copper Company's ores as a source of platinum.

Another source of platinum that has come under my notice is the "nickel oxide" manufactured by the Orford Copper Company from the matte produced by the Canadian Copper Company at Copper Cliff near Sudbury. This matte is the result of smelting nickeliferous pyrrhotite from the Copper Cliff, Evans and Stobie mines, and thus represents an average of the ore from a district some eight miles in length from southwest to northeast. One ton of the "nickel oxide" contains about 75 per cent. (dry weight) of nickel, and as the raw ore does not yield more than about 2½ per cent., each ton of oxide may be regarded as the concentrates from 30 tons of ore. In October, 1892, the Emmens Metal Co. purchased a parcel of some 18 tons of this oxide (representing therefore 540 tons of ore) and when engaged in refining the same I obtained a peculiar residue, which on examination by Mr. Mixer and myself proved to contain platinum in appreciable quantity. I accordingly sent a fair sample of the whole 18 tons of oxide to Mr. F. P. Dewey for analysis and he reported the precious metal contents to be as follows:

Analyses of nickel oxide.

Gold	slight trace.
Silver	1.00 oz. per ton.
Platinum	0.25 oz. per ton.

Prospecting for platiniferous ores in the Sudbury district encouraged.

It would appear therefore that some remarkable foundation exists for the impression referred to in the before quoted passage from the Census volume. It would also seem that a careful examination of the pyrrhotite deposits in the Sudbury district should lead to the discovery of small veins of arsenical ores traversing the greenstone dykes, and that these veins will, upon assay, prove to be platiniferous. I base this opinion upon three premises: first, sperrylite is an arsenide of platinum and occurs in one of the said veins; secondly, the vein at the Macdonnell mine in addition to chalcopyrite, folgerite and pyrrhotite, carried niccolite and gersdorffite, which are both arsenical ores; and thirdly, the "nickel oxide" above referred to contained an appreciable percentage of arsenic.

XIII.

LITHOGRAPHIC STONE.

By Dr. C. W. Volney of New York.

the last two years made extensive explorations of the
in the county of Hastings, and hereby report on some of
investigations.

Explorations in Hastings county.

that I could find but little in existing literature useful in
entification of good lithographic stone. Dana in his
"Lithographic stone is a very even-grained compact lime-
uff or drab color ; as that of Solenhofen." (Fifth ed. p. 679).
rable variety of limestones, all showing the above character-
few can be used by the lithographer. Experiencing diffi-
ection, I collected a number of acknowledged lithographic
ed them, and the analytical results and observations are
paper read at the Pittsburgh meeting of the American
in December, 1892, and an advance sheet from its journal
ne I enclose for the use of this report. It is as follows :

Scant literature on lithographic stone.

Chemical study of the stone.

in preparing this report I cannot give an exhaustive refer-
literature on this subject ; what I have been enabled to
give me the desired information, and in order to obtain
arison I analyzed some mineral from Germany. This was
ood quality. Lithographic limestone is the product of
l formations. If it is true that any limestone of fine, even
n the lithographer's art, it is equally true that such material
difficult to find, although we have immense tracts of
to select from. Of the various samples of limestone which
or lithographic purposes, many show in outward appearance
nblance in grain and structure to varieties known to be
vertheless worthless. To ascertain the real cause a physical
s insufficient, and on the other hand the chemical examina-
come under my notice, does not show sufficient grounds for
stinction. I quote here the analytical results given in the
Resources of the United States, 1893, as follows :

Stone of good quality difficult to find, and appearances are often misleading.

STONE FROM MISSOURI.

31.2
817.7
151.0
0.1

1000.0

STONE FROM BAVARIA.

44.5
814.7
138.3
2.5

1000.0

e would indicate any practical difference, and as it is
at in physical properties, fineness of grain, etc., these stones
her, a distinction for practical use could not be deduced from

Study of qualities by comparison

these analyses. To obtain however material for comparison I procured German stones of undoubted good qualities as lithographic stone, and selected two, one of dark blue and one of light yellow color, with these results:

DARK BLUE STONE FROM SOLENHOFEN.

Spec. gravity at 15.5°=2.952.

Analyses of German,

Insoluble silicate,	2.0000
Organic matter,	0.7200
$CaCO_3$,	90.9341
$MgCO_3$,	3.5710
Soluble silica,	0.5200
Al_2O_3,	0.5840
Fe_2O_3,	0.2360
FeO,	0.1300
Water,	0.4000
	99.951

LIGHT YELLOW STONE FROM SOLENHOFEN.

Spec. gravity at 15.5°=2.8388.

Insoluble silicate,	1.8930
Organic matter,	0.1320
Soluble silica,	0.0200
$CaCO_3$,	89.5390
$MgCO_3$,	4.3801
Al_2O_3,	0.1010
Fe_2O_3,	0.3210
FeO,	0.0030
Water,	1.3790
	97.7681

LIGHT GRAY STONE FROM KENTUCKY.

Spec. gravity at 15.5°=2.99331.

Kentucky,

Insoluble silicate,	11.500
Organic matter,	0.400
$CaCO_3$,	73.241
$MgCO_3$,	12.431
Al_2O_3, Soluble silica, Fe_2O_3,	1.141
Water,	0.935
	99.648

BLUE STONE FROM IOWA.

Spec. gravity at 15.5°=2.8173.

Iowa,

Insoluble silicate,	6.97500
Organic matter,	3.30000
$CaCO_3$,	82.20051
Fe_2O_3, Al_2O_3, Soluble silica,	1.07631
$MgCO_3$,	4.32703
Water,	0.24001
	98.11886

LIGHT GRAY STONE FROM MISSOURI.

Spec. gravity at 15.5°=2.7558.

Missouri,

Insoluble silicate,	4.300
Organic matter,	1.830
$CaCO_3$,	77.031
$MgCO_3$,	14.271
Fe_2O_3, Al_2O_3, SiO_2,	2.143
Water,	0.341
	99.916

GHT BLUE GRAY STONE FROM CANADA.

Spec. gravity at 15.5°=2.85156.

ate,	3.71200
r,	0.40910
	89.98900
	2.78932
)$_2$,	0.73101
	0.15302
	0.10431
	1.25000
	99.13776

and Ontario

DARK BLUE STONE FROM CANADA.

Spec. gravity at 15.5°=2.89104.

ate,	3.6000
r,	1.2900
	88.0341
	2.5000
	0.4900
	0.5770
	0.3590
	0.0410
	1.3601
	99.2512

lithographic stones.

Origin of organic matter in the stones.

at in a number of stones analyzed in drying at 100° a organic matter volatilizes and escapes with the moisture ones. In most cases therefore the quantity of water will at the expense of organic matter. The latter contains s of iodine, and is evidently the remnant of cretaceous ca may also originate from these fossils. It is certain that ins cause the difference in the color; in fact they form r of these limestones, and its presence does not seem to eans with the usefulness of the stone in lithographic art. presumed that the presence of this partially destroyed have had some influence on the peculiar precipitation, and e on the fine and even formation of these peculiar strata. ed by me and the work done so far does not justify a final is probably sufficiently strong to indicate it, and may give l tests. In all other respects, with the exception of some oo much silicious matter, the composition varies but little, are not pronounced enough to impair the quality of the ic purposes.

Age of lithographic stone.

influence may have been of this organic matter on the cium carbonate—holding this and other inorganic subon, retarding quick precipitation and thereby assisting in ven grained and dense strata under subsequent pressure— l that lithographic stone was formed during or after the ge and peculiar fauna, like the Jurassic and Silurian limeif further analytical work should confirm what my present to indicate, that this peculiar coloring matter is an good lithographic stone, an identification of the proper inal deposits would thereby be greatly facilitated.'

Exploiting the Marmora stone.

ed, this work was an outcome of my explorations in the istricts at Marmora. The dark blue variety of Canadian er about seventy feet below the general surface of the nora, showing at the borders of Crow lake. Here some rlying strata have been broken and washed away, not only es the different layers, but also enabling me to reach those evel of the lake. Of some twenty-seven layers examined ve encouraging results, and this is the dark blue variety, above. In the fall of 1891 I removed a number of large

Tests of samples by lithographic experts.

Works erected to prove the quality of stone in different layers.

sample stones from these layers and after proper preparation had these tested by lithographic experts. The mass itself proved to be excellent, and some stones of large size showed sufficient freedom from faults and especially from calcspar crystals as to encourage me to further proceedings. Finding that, for a proper and thorough investigation, machinery for cutting the stone was needed, I erected during the summer of 1892 at the quarry on lot 9 in the third concession of Marmora, buildings and machinery, and also derrick, etc., and from September until the end of November sawed and examined a considerable lot of stones from the layers of this quarry. I found layers, which are practically free from faults, especially free from the calcspar crystals, which have made so far all the lithographic stone from this district useless.

An older deposit than the Solenhofen stone, and therefore of greater specific gravity, but an excellent material.

The lithographic stone of this section is a product of a much older geological formation than the Jurassic, and therefore more dense and specifically heavier than the stone from Solenhofen, which is shown by the specific gravities as given above. Its composition compares most favorably with the blue German variety, and the practical tests prove it to be an excellent material for all the different processes employed in the lithographic art and second to none.

Dip of the strata below the level of Crow lake.

A large capacity of supply.

The layers exposed by my quarrying at Crow lake have been disturbed from their original horizontal position and dip at an angle of about 5° in a southerly direction, whereby at a short distance south from the quarry they run below the level of Crow lake and will therefore make quarrying in that direction impossible. The field to the north and northeast however is free to a considerable extent, and shows a large capacity of supply. I succeeded in finding these same layers at another location east of Marmora, and have made arrangements for the working of these deposits in a business-like manner, so that it may be expected that a considerable quantity will be quarried and prepared for the trade during this year.

XIV.

ONTARIO'S MINERALS AT THE WORLD'S FAIR.[1]

Dr. A. P. Coleman, Professor of Metallurgy and Assaying, School of Practical Science.

The history of the Province founded on its geology.

The history of the Province of Ontario is like that of every other country, gely founded on its geology. The southern part, with its level Palæozoic ks covered with good soil, one of the most fertile parts of the continent, s naturally first settled with farmers having the virtues but also the defects their class. The Silurian and Devonian rocks cropping out along rivers l lakes afforded building stone and lime for mortar, but very few other nerals of importance. If we mention gypsum, rock salt at great depths ow the surface, petroleum and a few deposits of bog iron ore, we have austed the list of minerals economically important in southern Ontario. ere is no coal for metallurgical or manufacturing purposes. There are no ily-worked placer mines to tempt her inhabitants into other lines of work. s not surprising then that Ontario produced a fine, sober-minded, moder- y prosperous race of countrymen, progressing quietly but steadily, afraid nazardous ventures in business, knowing nothing of mines and minerals, l of the fortunes won and lost in them.

The limit of rapid advancement reached by old methods.

New ventures are feared.

The Laurentian and Huronian country in the greater Ontario to the th and west was non-existent to the hard-working man of the south except region of barren rocks and muskegs, where you might get some good pine ber if the fires had not destroyed it, but that was worthless otherwise ause you could not farm it. In spite of its immense area Ontario has ched its limit of rapid advancement according to old methods, and yet its ple are afraid to venture on new and risky enterprises to develop the es of the mining country to the north. Many a farmer and villager was zled by the gold of the Madoc region years ago, and sank hundreds or usands of dollars in the vain search for gold. You cannot persuade these to risk their money again in a Canadian mining enterprise, no matter legitimate and safe. They have not learned the methods of handling matters profitably. For some time to come we may expect Americans, lishmen and everyone else except Canadians to develop and profit by our eral resources until we have time to learn from them and gather the know- e and courage to do our own mining and smelting.

The Chicago collection demonstrates the mineral promise of the Province.

If anything could rouse the people of Ontario to the importance of what beneath their soil, instead of nearly at its surface, it should be the admir- collection of minerals prepared for the Chicago exhibition. It is to be by no means complete nor perfect in spite of the efforts of that enter- ing and indefatigable collector, Mr. Boyle, who with the means at his dis- l has done wonders; but it is complete enough to show that Ontario is of the most promising mineral regions in the world. The collection has formed chiefly to illustrate the economic resources of the Province, and erly enough much more care has been taken to display a complete set of ores, building stones, etc., than to bring together a full series of the erals occurring in the Province, whether economically important or not. ertheless the mineralogist finds in the collection much that is of interest the purely scientific side.

Scope of the paper.

n describing the collection the building and ornamental stones will be ed briefly first, the crystallographic collection taken up next, and finally metals and their ores will receive attention.

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[1] A paper read before the Geological Section of the Canadian Institute in Toronto.

BUILDING AND ORNAMENTAL STONES.

Sandstones. Sandstones of good quality are represented from several parts of the Province, including several colors, especially gray, brown, red and banded.

Limestones. Limestones are present in considerable variety, including marls, lithographic stone, impure limestones suitable for hydraulic cement, and dolomitic or magnesian limestones.

Marbles. Among ornamental stones suited for monuments, pillars, etc., we find quite a variety of stones, often handsome in color. The marbles may be mentioned first, since they are most extensively represented. Marbles proper are exemplified in thoroughly crystalline specimens from the Grenville series of the Laurentian, but not sufficiently fine grained and pure in color to make good statuary marble. Less pure varieties, often hardly at all crystalline and colored with oxides of iron, clayey and bituminous matters, give a wide range of rich and often pleasing tints, uniform, or softly mottled, or boldly marked. Among them are found pinkish and deep salmon-colored stones, white mingled with gray or with green, combinations of brown and green, and dark gray or even black. Many of them take a fine polish and seem free from checks and fissures; and in all probability better samples will be obtained as the quarries reach greater depths below the surface influences of weather and frost.

Serpentine. With the marbles may be placed the serpentines of varying depths of green, and the mixtures of serpentine and whitish calcite, which display a pleasing set of soft colors.

Granite gneiss and syenite. Next to the marbles in importance are the granites and related stones, including gneiss and syenite. These have commonly in our Province tones of light or deep flesh red or purplish red, from the prevalent color of the felspar, but gray granite is also exhibited On the whole they are excellent stones of good color and take a fine polish.

Jasper. True porphyry scarcely appears in the exhibit, nor are the greenstones represented to any extent; jaspers of fine yellow and dark red tones are shown from Algoma, one under this head being really a red marble. The jasper conglomerate from Algoma with its red pebbles enclosed in white quartzite should make a beautiful ornamental stone, though difficult to work from its hardness.

Gneiss conglomerate. One of the most curious specimens exhibited is a kind of gneiss-conglomerate, consisting of gneissoid fragments enclosed in a schistose matrix, with varying soft tones of brown, purplish gray and green. This should make a handsome ornamental stone of a unique kind if it occurs in sufficiently large amounts.

THE CRYSTALLOGRAPHIC COLLECTION.

In taking up the crystallographic collection, I shall include such economic minerals as do not come properly under the head of ores, in this respect gaining unity of plan but deviating from the arrangement made by the authorities of the exhibition. The order followed will be that of Dana in his System of Mineralogy.

Graphite. Graphite is represented from several points in the Grenville series of the Laurentian, sometimes in bands or beds several inches thick, having a foliated structure, at others mixed with pyroxene or magnetite, and still more frequently disseminated as scales through crystalline limestone. The last combination permits the separation of the graphite in a very pure state. The association of graphite beds with the crystalline limestones is very interesting to the geologist, as tending to prove the existence of plants and animals in those remote ages, even if the organic nature of the Eozoon Canadense of the same rocks should be denied. Of the other forms of carbon, diamond has not been found in Ontario, and anthracite only as a rarity in small pockets.

nes next in order, most specimens in the usual form of **Molybdenite.**
ry much like graphite, but having a slightly redder metallic
interesting specimen is a large crystal from Renfrew
l prism in appearance, or perhaps rather two very sharp
l by basal planes. It has much the shape of some mica

urse a common mineral in the collection, and forms the **Pyrite.**
ystals with brilliant metallic lustre. The forms are of the
es, octahedra and pyritohedra, with some globular concre-
e cubes are an inch in diameter. The dimorphic form of **Marcasite.**
rcasite, occurs in Ontario near Port Arthur in fine speci-
te, which is grouped with the ores, displays moderately **Arsenopyrite.**
tals, isomorphic with marcasite.

haloid minerals fluorite and halite, or salt, are exhibited.
usual cubic form and handsome green, yellow and purple **Fluorite.**
iated with amethyst and with calcite and marcasite in
t Arthur.

salt, cannot be described as a mineral, since it is prepared **Halite.**
of brine and is not obtained in the solid form, though beds
feet thick exist in the west of the Province.

many forms in the collection, massive for metallurgical pur- **Quartz.**
tals in geodes, and as beautifully clear rock crystals often
senting the usual prisms, completed by two rhombohedra
, with subordinate trapezohedral planes. Some specimens
mal and distorted; others have regularly arranged inclu-
göthite. As associated minerals we find pyrite, limonite
iron, calcite, apatite and mica. Smoky quartz is shown
wnship, and the beautiful amethysts of Port Arthur are
The latter are often large and show a zonal structure with
lor. The growth by addition of material from without is **Amethyst, chalcedony and jasper.**
by specimens having a strongly colored inner pyramid
shell, a crystal within a crystal. The splendid purplish
ldom so uniform in distribution as to give stones fit for cut-
the Port Arthur amethyst we find common quartz, calcite,
e, galena and zincblende; some of the specimens making a
nerals in themselves. A little chalcedony and specimens
entioned with the quartz No other oxides are included
hic collection except a specimen of spinel in calcite from **Spinel.**
No examples are to be found in the collection, I believe,
ls, sometimes called Kaladar diamonds, which occur in
n the eastern part of the Province as fine octahedral crys-
spinels are transparent enough to serve as gems.

the commonest minerals, is of course represented by **Calcite.**
s with varying forms and colors. Some examples show
rms of dogtooth spar, others the prism ended by one or
, while many specimens of cleavage rhombohedra are
nples are almost ice clear, like Iceland spar, though none
quite flawless enough for optical purposes. It is greatly
ome new deposit of spar perfect enough for Nicol's prisms
replace the failing stores from Iceland. The ordinary
lcite is commonest, but a singular green variety is shown,
colored ones along with apatite from the phosphate regions.
als we find among others quartz, amethyst, fluorite, pyrite
xamples of other carbonates, such as dolomite or magne-
in the catalogue, though both I believe occur in Ontario.
r manganese spar is shown from McKellar island, near
scribed as argentiferous.

Manganese spar.

Orthoclase and microline.

Turning to the silicates, we find the potash felspars well represented. Besides large specimens of orthoclase with the characteristic rectangular cleavages and tones of flesh color or purplish gray, there are many examples of microclin, a triclinic form with a peculiar interwoven twin structure. Probably most of the large rough surfaced crystals from Sebastopol township are of this species, rather than orthoclase proper. There are several examples of green microclin, better known as Amazon stone, though not of specially fine color or crystalline form. One of the most beautiful minerals of the group is perthite, so called from the town of that name from its having first been found near there. It is really an intimate intergrowth of orthoclase or microclin with albite, a variety of plagioclase or striated felspar. Some of the polished specimens are of a very handsome deep flesh or orange red color, with yellowish gleams like aventurine or sun stone. This mineral should make pretty stones for sleeve links, brooches, etc.

Perthite.

Graphic granite.

Examples of graphic granite, an intergrowth of felspar with quartz, are common in Ontario, but scarcely represented in the collection.

Labradorite.

Of plagioclase proper few specimens are shown, a specimen of labradorite being the only one I find mentioned in the catalogue.

Pyroxene.

Pyroxene, or augite, is a very common silicate in the phosphate region, and is represented by numerous pale or dark green or black crystals, some of them very large and fine.

Tremolite and actinolite.

Hornblende, or amphibole of the ordinary dark green kind, is not largely represented, but its fibrous and acicular varieties, tremolite, which is gray or white, and actinolite, which is pale green, are shown as groups of long crystals or masses of radiating fibres. Some specimens might almost be described as asbestos, having slender parallel fibres, which are unfortunately brittle.

Sodalite.

Sodalite is a rare silicate of a blue color like lapis lazuli. Specimens are exhibited from Dungannon township, county of Hastings.

Garnets.

Garnets are very common in Ontario, and many specimens have found their way to the collection. They are chiefly the common dark wine or purplish red variety, almandine, but some rather fine examples of a yellow or brown garnet, probably essonite or grossularite, are shown. It is doubtful if any of our Ontario garnets are of gem value.

Scapolites.

Wilsonite.

The scapolites of the apatite region are of interest. Some are crystals of the usual form with primary and deutero prisms, pyramid and basal planes. They are gray or greenish gray and have a weathered appearance. The variety called wilsonite, which has a pretty rosy or pale purplish red hue, is found so far as I am aware only in the Ottawa valley, where it occurs in large masses, showing rectangular cleavage but not a definite crystal form. It received its name from Dr. Wilson of Perth, its discoverer.

Vesuvianite.

Vesuvianite comes from the Ottawa valley also, as brown crystals showing prismatic and pyramidal forms, sometimes with bright polished planes.

Zircon.

The zircons of Ontario are justly celebrated for size and beauty. Their crystals are frequently an inch square and have sharp, polished planes of a square prism and three pyramids. Splendid examples of geniculated twins, which are rarely found elsewhere, come from Sebastopol township. A very good example is to be seen in the collection. The colors are various tones of brown, wine color and reddish violet or lavender, and they often have a fine fire and lustre, though rarely clear and uniform enough to be cut as gems. These zircons are associated with felspar, hornblende, pyroxene and scapolite. It is perhaps worthy of mention that many of our granites and other rocks contain beautiful zircon crystals of microscopic size.

Cyanite and prehnite.

Cyanite is found as bluish blade-like crystals in the phosphate and other regions.

Prehnite comes next in the list with a specimen from the north shore of lake Superior.

Tourmaline.

Tourmaline is common in our rocks as the black variety, schorl. Speci- ens in the exhibition show the usual triangular striated prisms with rhom- hedral terminations showing hemimorphy. One specimen consists of slen- r radiating dark gray prisms. None of our tourmalines are transparent ough to furnish gem stones.

Micas.

Among the most interesting Ontario minerals are the micas, which include iscovite or potash mica, phlogopite or magnesium mica, and biotite or mag- sium iron mica. They all crystallize as prisms of the monoclinic system th a nearly hexagonal outline, and have an exceedingly perfect basal cleav- e, so that they may be split into elastic plates much thinner than a sheet of per. Muscovite specimens are comparatively few. They are much more nsparent than the other species and yellowish, or in one example green in or. A specimen of yellowish muscovite contains innumerable brown or netimes red plates of some other mineral between its cleavage plates. logopite, the best represented species, forms one crystal weighing 400 lb., l affords plates half a square yard in area. This mica is amber brown in n plates and dark brown or black in thicker specimens. Its use in stove ndows and as an insulator for electrical machinery make it a very valuable oduct. Phlogopite occurs almost regularly in association with apatite and accompanying minerals.

Muscovite.

Phlogopite.

Asbestos.

Serpentine belongs to the same group of minerals as mica, and though it been referred to under the ornamental stones the fibrous variety chryso- , or asbestos, as it is generally called, may be mentioned here. This fibrous riety occurs as veins in massive serpentine, the fibres being really minute sms arranged across the vein. Their fineness and flexibility are the most iking feature of the mineral, enabling them to be teased out and spun like or cotton. The greater part of the world's supply of asbestos now comes m the Province of Quebec, where the veins may be two or three inches le and of a beautiful green silky lustre. The specimens sent to the exhibit n Marmora have not so pretty a color, but show veins almost an inch le and with every appearance of good quality. If it should be found in ;e quantities, Ontario may divide the market with Quebec and Italy.

Talc.

Talc belongs to the same group of silicates, and forms pale green foliated sses with a pearly lustre and greasy feeling under the finger. Excellent mples of talc are found in the collection, as well as of steatite or soapstone, amorphous variety.

Kaolin.

Kaolin comes next in order, examples of the pure white material having n brought by Mr. Borron from the Missinaibi river, near the sea coast of ario on Hudson bay. As pure white quartz sand is found in the same on, porcelain may yet be manufactured and another Sevres rise on the res of Hudson bay.

Titanite or sphene.

The titanites or sphenes of Ontario are celebrated in museums, and excel- examples of all sizes up to portions of a 60 lb. crystal are to be found in collection. The smaller crystals are often beautifully perfect with brightly rous planes. Some are twins. The colors are various tones of brown, etimes with a fine yellow gleam. They come mostly from the apatite on and are associated with the same minerals.

Apatite.

Apatite is perhaps the best known mineral of the Ottawa valley, speci- ns of its enormous crystals being found in all the important museums of world. These crystals are not nearly so rich in planes as the small trans- ent specimens from the Alps, having as a rule only the prism and amid, though a deutero prism and the basal planes are sometimes added. stals from calcite often show gleaming polished surfaces, but generally e the edges rounded as though by melting or the action of a solvent. At es calcite fills holes or forms pebble-like inclusions in the crystals. The r is usually some tone of sea green or brown, though deep flesh red, pur- h red and even black occur. The Canadian apatites are fluor-apatites, containing about 3½ per cent. fluorine. They are probably as pure phosphates as exist in nature, containing from 70 to 95 per cent. phosphate of lime, but the easily handled Florida phosphates form such serious rivals that comparatively little mining is now being done. Our apatite is associated usually with calcite, often of a fine flesh color, greenish pyroxene, scapolite and wilsonite.

Barite and celestite.

Of the sulphates, there are numerous specimens. Barite is shown as fine tabular crystals, and as white masses, the latter from near Port Arthur. Celestite, strontium sulphate, occurs in our Province as large, transparent crystals from the limestone near Kingston, as deep salmon colored masses of plate-like crystals from the Credit valley, and as radiating masses of prisms from Addington.

Gypsum.

Gypsum occurs in southwestern Ontario, and also in the Moose river region to the north as selenite in large cleavage sheets or as massive crystalline varieties.

In concluding this rapid survey of the crystallographic collection it is worth while perhaps to note the absence of some groups of minerals, such as the minerals containing rare elements found in the phosphate and pegmatite veins of Norway, which in many respects are very like those of the Ottawa valley. Do these minerals not occur in Ontario, or have they simply not been carefully looked for?

Absence of some groups.

The absence of true gems from the list is rather surprising, though of course the gathering of mere rarities and curiosities was not intended in forming the collection

Turning up Kunz on Gems and Precious Stones, I find mention of twenty-eight Ontario minerals that might be used as semi-precious stones, but none of true gems. Beside those that have been referred to in the previous notes, I find corundum as red and blue crystals in limestone from Burgess, pale green crystals of beryl from Rainy river, yellow tourmaline from Ross, agate from Michipicoten island, epidote and green prehnite from lake Superior, the moonstone or albite with bluish opalescence from Bathurst and Burleigh; pyrite, scapolite, ilvaite, zonochlorite and thompsonite. The emerald, ruby, precious opal and diamond seem not to occur in our Province.

NATIVE METALS AND ORES.

Tin.

Bismuth and antimony.

All the important metals are found in Ontario, though not always in appreciable amount. Tin has I believe hitherto been observed only in minute quantities as cassiterite in connection with the platinum ore of the Vermilion mine; and bismuth chiefly in a few rare minerals or in specks of the native metal from Pierre Plat, lake Superior. Antimony too is rare, though stibnite has been found in Marmora in Hastings, and Sheffield in Addington county. Mr. Dewar's analysis of an obscure mineral from Barrie township shows 20 per cent. of antimony.

Platinum.

Sperrylite.

Platinum exists in small quantities in the Vermilion mine as the arsenide, sperrylite, but perhaps not in workable amounts. Up to the present the world's supply of platinum has come mostly as nuggets and dust from Russian placer mines; and as it is a valuable and costly metal, the discovery of workable deposits of its ore would be of great interest. Sperrylite is a tin white arsenide of platinum ($PtAs_2$), apparently isomorphic with pyrite. It has a brilliant metallic lustre, a hardness almost equal to quartz and the high specific gravity of 10.6. It contains besides platinum and arsenic traces of rhodium, palladium, iron and antimony, with some oxide of tin, the latter probably an impurity. It occurs with gold ores, pyrite, chalcopyrite and pyrrhotite.

Zinc and lead.

Two of the commoner metals, zinc and lead, occur in large deposits in Ontario, but at present are not mined or only in small quantities. Zinc is und chiefly if not wholly as the sulphide, sphalerite or zinc blende, on the rth shore of Lake Superior, in veins from 2 to 16 feet wide. Lead also is und as the sulphide galena in several parts of the Province, and has been ined north of Kingston and smelted at that city.

Manganese is found in pyrolusite, a specimen of which is in the collection.

Manganese.

Iron ores.

Magnetite.

Hematite.

Limonite.

A rare occurrence.

The most valuable and yet the cheapest metal of all, iron, occurs in inexhaust- le quantities in our Province, chiefly in the ores, magnetite, hematite and nonite. Magnetite containing 65 per cent. iron with only traces of sulphur and osphorus, declared to be equal to the best Swedish ore, is found in Belmont, avant and other townships toward the east of the Province, and also in the est at the Atik-okan range. In Marmora a porous, weathered variety is a rong natural magnet and readily attracts small pieces of iron. Its magnet- n has no doubt been induced by the earth's magnetism. Hematite, massive, ecular, micaceous, etc., has been found of good quality at various points in e Ottawa valley and west of Port Arthur. Limonite or bog ore occurs at owdon and various other localities in the Province. It is the only metal- erous mineral of importance found in the southwest peninsula of Ontario. oth hematite and limonite occur in ocherous varieties adapted to make ineral paints of yellow, red and brown shades. Siderites and clay iron ores not appear to occur in Ontario in any large amount. It is greatly to be gretted that at present, with its immense stores of excellent ore, the Province ines little or none and smelts no iron, although iron was smelted at Marmora d other points in Ontario many years ago, and first class charcoal iron is w being produced at Radnor Forges in Quebec with no better ores or el. The occurrence of metallic iron in very peculiar concretionary globules St. Joseph's island, lake Huron, has been described by Dr. Hoffman. No nilar occurrence is known in other parts of the world.

Silver ores.

Native silver.

Argentite.

Animikite, Macfarlanite and Huntilite.

A curious Barrie mineral.

With the exception of argentiferous galena, the silver ores of Ontario are iefly from the Animikie rocks near Port Arthur. Native silver occurs metimes in large quantities in the mines about Port Arthur, and very hand- me specimens have reached the collection, including white or yellowish ates and wire associated with white quartz, amethyst, purple fluorite, lcite, barite and such metallic minerals as argentite, blende, galena, pyrite d chalcopyrite. Fine octahedral crystals of silver have been obtained near rt Arthur. Argentite or silver glance, the black sulphide, occurs as commonly silver itself and in much the same forms, plates, wire, and also as apparently norphous masses. I am not aware that crystals have ever been observed Canada. A specimen of animikite, a compound of antimony and silver $_9$ sb), associated with manganese spar, comes from the famous Silver Islet ne. The other two little known related minerals, macfarlanite and huntilite silver arsenide) from the same mine are not mentioned in the catalogue. The rious mineral from Barrie township in Frontenac county, analysed by Mr. ewar and found to contain among other things 1 per cent. of silver and over per cent. of copper, may be mentioned here. Whether it is a mixture of nerals or a definite compound deserving a name for itself one can hardly y at present.

Gold ores.

Native gold, which is of course the most important source of the metal, quite widely spread, especially in the Huronian rocks of the Province. ecimens associated in the usual way with quartz, oxides of iron and pyrite e found at many points, especially in the Madoc and Marmora region, the dbury region and Lake-of-the-Woods. Curious specimens of gold thout quartz in green chloritic or hornblendic schist come from lake Wah- pitae. A very refractory ore of gold, arsenopyrite or mispickel, once mined large quantities near Deloro, is well represented in the collection, and there a specimen of a rare telluride ore, sylvanite (AU Ag Te sb Pb), from the uronian mine, Moss township, west of Port Arthur. About the only mine regular operation in the Province seems to be the Belmont mine, worked by the South African Mining Company near Marmora, though one hears of the Sultana and other mines on Lake-of-the-Woods, of the Ophir mine in Galbraith township, the Vermilion and other mines that promise more or less well. It is rather surprising to find no placer mining region in the Province, though perhaps all deposits of this sort were swept away or buried by the ice of the glacial epoch.

Copper ores.

Chalcopyrite.

Malachite, azurite and cuprite.

Copper ores are widely found in the Huronian and immediately overlying rocks, including considerable quantities of native copper in irregular masses and plates associated with calcite, prehnite and laumontite. This native copper from Mamainse and other points north of lake Superior is precisely like specimens from the famous Michigan copper mining region to the south. Native silver is sometimes found welded to the copper but not alloyed with it, which proves that the metals were deposited from solutions and not in a state of fusion. The commonest copper mineral is chalcopyrite or copper pyrites, which is found in great quantities with pyrrhotite in the nickel region. Other sulphides represented in the collection are erubescite or bornite, well known for its peacock colors, and chalcocite or copperglance. The carbonates, malachite which is green and azurite which is blue, occur only sparingly. Cuprite, the red oxide (Cu_2O), appears associated with some specimens of native copper as small but brilliant crystals. At the present time none of these ores are being worked except incidentally in the production of nickel.

Nickel ores.

Pyrrhotite.

Gersdorffite.

Niccolite.

Blueite.

A large part of the world's supply of nickel is now produced in the Sudbury region, the only rival which Ontario has in this respect being the French colony of New Caledonia in Australasia. On this account the nickel ores of the Province have a special interest. Pyrrhotite, a bronze-colored magnetic sulphide of iron (Fe_6S_7 or Fe_nS_{n+1}) is by all means the most important of these ores, though it contains only two or three or at most a few per cent. of the metal, since it is found in enormous masses. This ore seems regularly connected with eruptions of diorite, diabase or gabbro in or beside Huronian rocks. It is not limited to the Sudbury region, since specimens come from near Rat Portage also. Analysis of Sudbury pyrrhotites prove them to be on the whole much richer in nickel than the same mineral from other parts of the world. So far as I am aware, no crystals of the mineral have been found in Ontario, although it is present in such vast deposits. In other regions tabular hexagonal crystals have been found as a rarity. Comparatively few nickel minerals proper occur in the Sudbury region, niccolite, gersdorffite and three newly-discovered minerals appearing to complete the list. Millerite was reported from the region, but the mineral was probably incorrectly named, since it formed only crystalline masses with a tabular cleavage, quite unlike the slender brass-yellow needles and radiating structures found in millerite from other parts of the world. The specimens which I have seen are probably folgerite. Gersdorffite, a sulph-arsenide of nickel ($NiAsS$), occurs as silver white or steel gray octahedra in niccolite and pyrrhotite from the Gersdorffite mine not far from Sudbury. It is very rich in nickel, but its amount is insignificant. Niccolite, sometimes spelt nickelite or nickeline, the arsenide ($NiAs$) is pale copper red in color when untarnished, and the richest ore of nickel found in our region (43.9 per cent.) It occurs with the previous minerals at the Gersdorffite mine. Three interesting new minerals have been described within the past year by Dr. Stephen Emmens, president of the Emmens Metal Co., of Youngwood, Pennsylvania. Folgerite (formerly called millerite) is a sulphide of iron and nickel ($NiFeS_2$), light bronze yellow, massive, with a platy structure, non-magnetic. The specimens come from the Worthington mine and form a very rich ore of nickel (Ni 31.45 per cent) Blueite (named for the efficient Director of the Ontario Bureau of Mines) is pale olive gray inclining to bronze in color and non-magnetic. It is probably a mixture of nickel and iron bisulphides (NiS_2 FeS_2) with 3.7 per cent. nickel.

ronze yellow and cellular in structure, only partly mag-
ins 5.79 per cent. nickel with the formula $NiS_2\,7FeS_2$.
ot an independent mineral, but a mixture. It is rather
e of the green silicate ores of nickel such as garnierite,
in New Caledonia, or genthite, formerly an important
States, have been found in any amount in Ontario, though
on Michipicoten island. Another point worthy of remark is
oportion of cobalt found in our nickel ores, usually only a
urope cobalt ores almost regularly accompany those of nickel.

FOSSIL FUELS.

Peat, lignite and petroleum

nce should be made to the fossil fuels displayed in the collec-
ese are comparatively unimportant. They include peat
he last is a woody brown coal like some mined in
e seams of it are proved to exist in the Moose river region
for that part of the Province is solved, but as it is found only
osits widespread beds are scarcely to be looked for. Our
um is confined chiefly to the county of Lambton, though it
he county of Kent.

A MUSEUM OF MINERALS.

Species represented in the collection.

ed about 70 distinct species of minerals represented in the
on sent to Chicago. In my reading I have found about 150
l to from Ontario localities, some 70 or 80 of which are not
Many of these have been found only in minute quantities,
any economic importance, so that the collection represents
lly the mineral resources of the Province, and will undoubtedly
calling the attention of the world to our undeveloped wealth.

Importance of a Provincial museum.

exhibit on its return should be placed in some convenient
nto as the foundation of a Provincial collection worthy of
as ours. To it should be added from time to time new spe-
he Ontario minerals are well represented in it.
f foreign minerals should be arranged in the same museum for
the whole should be open at suitable times to the public so
ople may learn what a heritage they have and be willing to
developing Canadian mines instead of Mexican ones.
has been prepared giving a list of all the species of minerals
e literature of the subject as far as examined in the prepar-
per. A few doubtful ones have an interrogation point after
v others are rather synonyms than distinct species. The
red to in preparing the list have been chiefly the Geological
especially Dr. Hoffmann's list, and Prof. Chapman's works.

LIST OF MINERALS FOUND IN ONTARIO.

, Thunder bay.
ke, S. Muskoka river.
astopol.
perior.
lende.
re lake Superior.
slet.
Superior.
perior.
nora.
ntain cork and leather) a
ende, Beaver mine, etc.

Asphaltum, Lambton Co.
Augite.
Aventurine.
Axinite, boulder, Prescott Co.
Azurite, Batchawana bay and Prince's mine.
Barite, McKellar island.
Beryl, Rainy lake.
Biotite.
Bismuth, native, Hastings Co., etc.
Bismuthinite.
Bismutite.
Blueite.
Bog iron ore.
Bornite, lake Huron.
Bournonite, Marmora and Darling.
Cacoxenite, near Brockville.
Calcite, Lanark, etc.
Cassiterite, Vermilion mine.

Minerals found in Ontario.

Celestite, Kingston, Credit Valley.
Chalcedony, lake Superior.
Chalcopyrite.
Chert.
Chlorite.
Chondrodite, Leeds Co.
Chrysocolla, lake Superior.
Chrysotile.
Copper, native, Mamainse.
Coracite, Mamainse (pitchblende partly altered to gummite).
Corundum, light blue and rose red, Burgess.
Cuprite.
Cyanite.
Datolite, Lacy mine, Loughboro'.
Diallage.
Diopside.
Dog-tooth spar.
Dolomite, Niagara.
Domeykite, Michipicoten island.
Eleolite, drift.
Epidote, Mamainse.
Epsomite, Marmora.
Erythrite, Prince's mine, lake Superior.
Essonite ?
Fluorite, lake Superior.
Folgerite.
Galena.
Garnet.
Genthite, Michipicoten.
Gold, native.
Graphite.
Gypsum.
Halite.
Hematite.
Hornblende.
Humboldtine, Kettle Point on black shales.
Huntilite ?
Huronite (altered anorthite) near Sudbury.
Hypersthene.
Iceland spar, St. Ignace Island, lake Superior.
Ilmenite ?
Ilvaite ? Ottawa.
Iron ocher, Grey Co., Simcoe Co., etc.
Isarite, part of black magnetic sands.
Jasper.
Kalinite, near Kaministiquia.
Kaolinite.
Labradorite, lake Huron.
Laumontite, north shore of lake Superior.
Lead, native, Kaministiquia.
Lepidomelane, Marmora.
Lignite.
Limonite.
Macfarlanite ? Silver Islet.
Magnetite.
Malachite.
Malacolite or Diopside.
Marcasite.
Martite, Bass lake.
Melanite.
Melanterite, lake Superior and Hastings.
Meneghinite, Marble lake, Frontenac.
Meteoric iron, Madoc.
Microclin.
Millerite ?
Molybdenite, Ross.
Molybdite, Ross.
Morenosite, Wallace mine, lake Huron.
Muscovite.
Niccolite, Michipicoten and Sudbury.
Oligoclase, Lanark.
Orthoclase.
Pargasite, Renfrew Co.
Pearl spar=Dolomite, in cavities and geodes Niagara formation.
Pectolite, Thunder bay.
Peristerite or albite, Bathurst.
Perthite, North Burgess.
Petalite, Toronto (boulder).
Petroleum.
Phlogopite.
Pitchstone, Michipicoten.
Polydymite, Sudbury.
Prehnite, lake Superior.
Pyrallolite, Ramsay and Rawdon.
Pyrite.
Pyrolusite.
Pyroxene.
Pyrrhotite.
Quartz.
Raphilite.
Rhodochrosite.
Rutile, Madoc.
Sahlite ?
Scapolite.
Selenite.
Serpentine.
Siderite, lake Superior.
Silver, native.
Smaltite, McKim.
Soapstone.
Sodalite.
Sperrylite.
Sphalerite.
Spinel.
Spodumene, boulder near Perth.
Stibnite, Marmora, etc.
Stilbite ?
Sulphur, native, Clinton.
Sylvanite, lake Superior.
Talc.
Tetrahedrite ?
Thompsonite (zeolite, Chap.) Mamainse.
Titanite.
Tourmaline.
Tremolite.
Uraconite, Madoc and Snowdon on iron ores.
Vesuvianite.
Wernerite=Scapolite.
Whartonite.
Wilsonite.
Witherite, Twin Cities mine, lake Superior.
Wolframite, gneiss boulder, lake Couchiching.
Wollastonite, North Burgess, etc.
Zircon.
Zonochlorite, Nipigon bay.

XV.

HE UTILIZATION OF PEAT.

Interest in the subject.

Production in Germany, Holland and Sweden.

Cost of production.

:h was noted in the Report of the Bureau for 1891 as hav-
estion of a possible supply of cheap and efficient peat fuel
n maintained throughout the past year. In the absence
ances of the Province are such as to require that all avail-
uld be obtained on the subject, and all the light derivable
of other countries cast upon it, in the hope that such a
coming. Prospects are held out that a manufactured peat
n the market during the present year at a price which will
successfully with coal, and it may be that a solution of
as been a perplexing one to experimenters is at hand.
w as to the use of peat at the present moment in various
ntal Europe encourage the hope that some method may be
ns of which our extensive peat bogs may be made to serve
as those of Germany, Holland or Sweden. The differ-
st of labor in Germany or Sweden and Ontario, though
it would seem, so great as to make it impossible to pro-
imilar quality here at a comparatively small advance in
he cost of producing well-made turf for fuel is placed at
on according to price of labor, this being the principal
ng the necessary additions for other charges and for the
r in Ontario, there would appear to be still considerable
fitable production at a selling price much below that of
the average rate of wages paid to men at the Government
Carolinenhorst moor is said to be $1 to $1.12 per day—a
t markedly so, to wages paid for corresponding work in
peat produced there is sold in competition with the plenti-
raised from the coal pits of Germany itself, while in On-
ion would be with coal burdened with freight charges for
eds of miles, besides the customs duty. National habits
ount for something, but adherence to old established ways
lf explain the vigorous survival of the peat industry in
the thrifty Dutch, Germans and Swedes find it to their
peat instead of wood or coal, it is worth while for the
o consider whether or not they cannot replace some of the
in their stoves and furnaces with a product of their own
.

Peat fuel discussed by the Mining Association of Quebec.

f the General Mining Association of Quebec held at Mon-
h April, 1893, the subject of peat was under discussion, two
one by Dr. R. W. Ells, LL.D., of the Geological Survey of
her by Thomas W. Gibson of this Bureau, both of which
l. Dr. Ells' interesting paper deals with peat and its pro-
ibson's, it will be observed, treats of peat as a fuel only.

IE PEAT INDUSTRY IN CANADA.

Ells, LL.D., of the Geological Survey of Canada, Ottawa.

e of the peat deposits which are found in all the Provinces
g been recognized, and a number of attempts have been
time to turn them to profitable account. Some of these
riod given fairly satisfactory results, but all have owing to
dually been abandoned. At present however there appears

to be a growing interest in the question of their utilization, and it is to be hoped that profiting by the mistakes and experience of the pioneers in the industry some more practical scheme than has yet been in operation may be devised, so that the manufacture of peat either for fuel or other purposes may be placed on a paying basis.

INTEREST OF ONTARIO AND QUEBEC IN PEAT.

Fuel resources of Ontario and Quebec.

This industry has a more important bearing upon the Provinces of Ontario and Quebec from the fact that while the inhabitants are here largely engaged in manufacturing pursuits requiring a large supply of fuel, it has long been a settled question that in neither of these Provinces can any natural supply of coal be expected. In Ontario this lack of coal for fuel may be to a certain extent met by the use of crude petroleum burned in properly constructed grates, and the experiments already instituted in that direction have shown that for heating and the generation of steam this substance possesses very many admirable qualities. In Quebec however this source of supply appears to be unavailable in so far at least as the researches in the Gaspé district, which may be regarded as our only oil field, have proceeded. Natural gas has also of late years entered the field as a possible competitor in the matter of fuel, more particularly in the Province of Ontario, though wells giving a limited flow of gas have also been bored at different points in the St. Lawrence area east and north of Montreal. This source of supply however does not meet the requirements of the case as satisfactorily as could be desired, owing doubtless to some extent to uncertainty as to its persistence, and also to the fact that it is unsuited to many purposes requiring a solid fuel. The fact also that the nearest available sources of coal fuel in eastern Canada are situated in the Province of Nova Scotia, the nearest of which to Montreal is about 700 miles by rail, while the great areas of Pictou and Cape Breton are still more remote, must also be carefully considered in the discussion of such a question as the utilization of the peat deposits near home. True it is that the adjacent Province of New Brunswick has a very considerable development of carboniferous rocks, and has been quoted by many as a great source of future supply of mineral fuel; but from a careful examination of that country it must be remarked that owing to the thinness of the coal seams, rarely more than twenty to twenty-two inches, and the peculiar soft character of the coal itself which unfits it for much handling, as also for other purposes for which a good coal is now required, the utilization of this fuel must be to a very large extent merely local. The other remaining sources of supply, more especially for Quebec, are the distant coal fields of the British islands, from which during a certain portion of the year fuel can be cheaply brought at a low rate of freight, so cheaply in fact as to enter into close competition with the output of the Nova Scotia mines, and the deposits in the United States from which, owing also to canal transportation, fuel can be laid down at certain seasons almost as cheaply as from the lower Province. Still the fact remains that freight rates, both from Nova Scotia and the Pennsylvania fields, are such as to make the price of coal fuel laid down in the manufacturing cities of Ontario and Quebec so high that many of the manufacturing and mining industries in both these Provinces are seriously hampered owing to the comparatively great expense involved in keeping our steam engines in motion and in producing the power necessary to successfully and cheaply carry on the various industries of the country.

Petroleum.

Natural gas.

Coal of the lower Provinces

and the British islands as sources of supply.

The cost of coal a burden on industries.

FEATURES OF A PEAT INDUSTRY.

Conditions of competition with other fuels.

The value of the peat deposits must however after all be merely a comparative one. If it can be conclusively shown that a peat fuel can be produced possessing let us say 100 heat units, and placed in the markets of Ontario and Quebec at a well defined less rate as regards cost than 100 heat units of coal, taking the coals of Nova Scotia and the United States in ordi

ndard, then it should be apparent that our peat deposits
tion as an important factor among the manufacturing or
ents of the day. To do this however we must first of all
y important features of the industry, such as the extent
, the calorific power of well prepared peat fuel, the con-
g and the advantages it possesses, if any, over the fuel at
osal, and in addition to this, and this is an especially
cost of its manufacture.

Its value for sanitary purposes,

n of our peat bogs we must bear in mind the fact that
question possess an equal if not even a greater present
n that of fuel supply. For instance the question of the
to sanitary purposes for the reception and economic dis-
ge of our large cities is now being largely considered, and
ned that in this respect no substance yet known possesses
or more valuable properties than the produce of our peat
led as practically valueless. Further, a comparatively new
into prominence in connection with these deposits, which
where has already reached a very extensive development,
lso permit handsome returns on capital in this country,
re of moss litter. This material from its great absorbent
found to surpass all other substances in the utilization of
r promoting the comfort and cleanliness and as a conse-
of all animals there kept. So great is the importance of
t comparatively unknown in Canada, that the peat bogs of
pplying the markets of London and New York with this
r, with a demand apparently unlimited and at a price
on market of 21 to 26 shillings per ton according to quality,
h highly remunerative results.

and for litter.

DEPOSITS OF ONTARIO AND QUEBEC.

Early investigations by the Geological Survey.

f the Geological Survey for 1845-46 attention was directed
t deposits, and the results of the investigation in this sub-
Hunt appeared in subsequent reports. Among these of
are the articles in the Geology of Canada, 1863, and in
In the pamphlet prepared for the Paris Exhibition, 1878,
is presented, more particularly relating to the trials
deposits east of St. John's in connection with the Hodges
Hubert in the county of Chambly, at which places very
cellent peat occur. A very considerable quantity of pre-
uced at these places, aggregating in 1875 about 13,000
amount being used for domestic purposes, while the rest
e Grand Trunk Railway for their locomotives. Changes
vever appear to have acted unfavorably as to the con-
ustry, and since that date but little has been done in this
quantity of prepared peat was also produced about the
Lewis in the county of Huntingdon, as well as at New-
Hope, in Ontario. Unfortunately no reliable data as to
ture at either of these places are at hand, and no subse-
appears to have taken place.

Working the peat bogs of Quebec.

deposits of Quebec and Ontario are known to be very
er part of these have hitherto remained untried. Among
be mentioned for the latter Province the vicinity of the
lying to the south of the Ottawa in the township of
f Prescott, and certain bogs in Clarence, Cumberland and
er in the county of Carleton. Of these the nearest the
e Mer Bleue, which consists of two long peat bogs, sepa-
idge of higher land and comprising in the two an area of

Bogs of eastern Ontario,

not far from 5,000 acres. These bogs were sounded by Mr. James Richardson of the Geological Survey staff and shown to have a depth in places of over twenty feet, the depth elsewhere ranging from five to fifteen feet. Three other large areas from 1,000 to 3,000 acres each occur in the townships of Nepean and Gouldburn adjoining, while other extensive bogs occur in Huntley and Westmeath. The depth of peat in these deposits varies from eight to over fifteen feet. Further south in the direction of Cornwall bogs are found in Osnabruck, Roxburgh and Finch, so that it is easily seen that a practically inexhaustible supply of material is found in the almost immediate vicinity of the Ottawa and St. Lawrence and in close proximity to the leading manufacturing centres. In western Ontario also peat bogs have been noted at many points, as in the vicinity of the Welland canal, and near lake St. Clair, as also in the counties of Simcoe and York, and farther west along the line of the Canadian Pacific Railway north of lake Superior, as well as on the route between that lake and Winnipeg.

and of western Ontario.

Inexhaustible supplies also occur in the Province of Quebec, as in Chambly, St. Hubert and in St. Brigide, where works have already been in operation. On the line of railway from Arthabaska to the St. Lawrence, opposite Three Rivers at Bulstrode, a bog was also formerly worked quite extensively, the product as air-dried peat being used on the Grand Trunk railway, as also in Huntingdon, Champlain, Lacolle and Sherrington, where a very thick deposit of excellent peat particularly worthy of notice is found. East of Valleyfield also and in St. Dominique extensive deposits occur; while on the north side of the St. Lawrence they are known in the townships of Grenville, Harrington, Mille Isles, St. Anne de Plaines, St. Sulpice, and Lavaltrie and St. Maurice. On the lower St. Lawrence peat bogs are found at River Ouelle, Isle Verte, Daquam, Matane, Macnider and other places; while on the island of Anticosti an immense bog estimated at nearly 200 square miles in extent occurs on the southwest coast, much of which is reported of excellent quality. From this brief enumeration of a few localities it is easily seen that the quantity of this possible fuel in Quebec is also practically unlimited.

Extensive bogs in Quebec.

ORIGIN OF PEAT BOGS.

How bogs are formed.

Peat bogs are all of vegetable growth, consisting for the most part of the decomposed remains of plants and mosses, chiefly of the genus sphagnum, which have apparently filled up the basins of shallow lakes. The deposits are frequently underlaid by a layer of shell marl, which has constituted the original lake bottom. The peat bog frequently carries a growth of trees, often of tamarac in a stunted condition, with various heath plants, which by the decay both of their stems and rootlets help to swell the organic constituents of the mass. In bogs of a good depth the peat may be divided into three classes, viz: (1) the green living and growing surface, (2) the intermediate zone in which the remains of the plants are well defined, but which is capable of furnishing an excellent peat for certain purposes, and (3) the lower and fully digested material in which traces of organic life are comparatively rare, which possesses a rich black or brown color, and when free from inorganic matter furnishes a fuel of very excellent quality.

Three classes of peat.

Character of peat.

In character also peat varies somewhat owing to the nature of the underlying rocks. Thus moss peats are generally found on rocks nearly free from lime, such as granite or other strata rich in silica, while grassy or sedgy peats are more frequently found in calcareous districts. In the ripest or most thoroughly formed peat the decomposition of the organic matter has reached the last stage, the result being a dark brown or black homogeneous mass, comparatively dense and heavy. This when moist is firm, sticky and coherent like clay, and can be readily cut and moulded into any shape, and when dried it is hard, having on cut or burnished surfaces a lustre like pitch or wax.

Best peat found in the lowest bed.

opment or exploitation of a peat bog for fuel it will apparently
nake use of that portion which is freest from organic remains,
occupies the lowest of the third strata just described, and in
nts upon the large scale possibly it may be found that some
ccess which attended these efforts was due to the attempt to
r portion rather than that most adapted to the manufacture

Upper portion valuable for moss litter.

In this connection it may be wise to consider also that it is
utilize the upper portion of the bog as well in the prepara-
litter, though the only attempt to develop this industrry in
I can learn has been in New Brunswick. There several years
ere begun on a peat bog about fifteen miles west of St. John, at
usquash. The promoters were capitalists from St. John and
a brief account of their operations will be found in the report
l Survey, 1889, by Mr. R. Chalmers. No attempt however
anufacture a peat fuel, owing presumably to the facilities
is place for obtaining bituminous coal from the adjoining
va Scotia, the freight from the mines in Cumberland county
order to show however what has been attempted in this
here quote a brief extract from the report just referred to.

Utilizing New Brunswick peat for litter.

e, moss litter, is used in stables as bedding for horses, etc., and
in the principal cities of the United States have been looking
f this kind prepared from the peat found on this side of the
t they require is a spongy moss, sufficiently light and porous
nt of the liquids and ammonia which collect in stables, and
g used in this way would make a fertilizer for gardens, etc.
ving purchased the bog at Musquash are now, 1889, erecting
achinery there for the preparation of the article. They claim
oss found in this locality is well adapted for the purpose
equally as good as the German moss litter. Hitherto a large
and capital has been spent by the Musquash company in
nd testing the suitability of the different grades of peat or
btained here for the purpose in view, and it has been found
ut half decayed, i.e., sufficiently so to be changed to a dark
ered somewhat short in the fibre without being absolutely
st. This kind of peat is not found in the upper or living
the deep-lying rotted material, but between the two, where
rootlets are partially decomposed and the fibres strong enough
mass from crumbling to pieces. The chief process in its
hat of depriving it of the water, of which it contains from
y-five per cent. This is effected partially in the pit by a
a plunger. The moss is then brought by tramways into a
bjected to great pressure by passing between heavy rollers,
sidual moisture is driven off by evaporation, after which it is
s for shipment."

pt to manufacture a compressed peat fuel of the first quality,
ied product, it would be well therefore to take into careful
e question of utilizing this second layer of say four to five
rpose just mentioned, since it should if properly managed
source of profit as the manufacture of the fuel itself, while it
at portion of the bog best adapted for the latter purpose to be
l economically operated.

Objects to be aimed at in the preparation of peat for fuel,

rawbacks have hitherto been found in regard to the utilization
on a commercial scale, viz., the great bulk of the air-dried
uiring great storage facilities as well as excessive charges for
he contained water, which even in the best air-dried qualities
20 per cent. This contained water must of course greatly

and difficulties to be overcome.

diminish the calorific value of the fuel, and it is the practical impossibility hitherto experienced of reducing this great percentage of contained moisture without very considerable expense which has apparently interfered with the successful economic use of the fuel in our manufactories and locomotives. In the matter of contained water air-dried peat ranks on a par with the best qualities of air-dried wood, but possesses this disadvantage that it contains a much greater quantity of ash, and also has a marked tendency to absorb moisture very readily, a feature which it is apparently very difficult to guard against. In the digging of peat also the precaution must also be taken to provide against the action of frost, since if frozen when wet its coherence is destroyed and it becomes useless as an air-dried fuel.

It is evident from a careful examination of the tests already made of our peat deposits that the objections already mentioned in regard to the air-dried product practically exclude it from the market unless for purely local consumption, and the future course of the industry as regards the fuel question must be along the lines of producing cheaply a thoroughly good compressed article.

Quality of the raw material an important consideration.

In this connection due care must first of all, as already suggested, be paid to the quality of the raw material used. For while simple pressure will reduce the peat to a much smaller bulk, if the material is originally light and porous its natural elasticity will tend when once the pressure is removed to restore it to its normal condition. It has also been found in practice hitherto that the machines employed, no doubt in some cases owing to a lack of proper preparation of the raw material before subjecting it to pressure, have failed to thoroughly remove the contained water; and this has of necessity, if a drier article is required, to be removed by the application of artificial heat at a considerably increased expense, the value of the fuel however being found to be greatly increased by this action.

Comparative value as a fuel.

As regards the specific gravity of the peat, this depends principally upon its position in the bog, and when uncompressed ranges from .25 to .9. In deep bogs a first-class peat of dark blackish or brown color and earthy fracture should have a gravity of .6 to .65. In carbon contents it ranges from 51 to 63 per cent. of the organic matter, its quality being due to its density and ripeness. From a series of experiments conducted by Prof. Johnson of the Yale Scientific School, it would appear that weight for weight the ordinary qualities of peat do not differ very greatly from wood for heating purposes. By compression its heating properties are very greatly increased. Thus it was found that while a good peat cut and air-dried had a heating value of .80, the same condensed and containing 10 per cent. of water had a value of 1.48, and made into peat charcoal the value was increased to 1.73. Compared with wood, this value was found to range from .50 for poplar to 1.18 for summer oak. As compared with anthracite, tests made by the Water Department of Brooklyn showed the ratio of peat to this fuel to be as 1 to 2.25, and a table prepared by Prof. Johnson showing the comparative composition and gravity of peat, wood and anthracite is as follows:

	Carbon.	Hyd.	Ox. & Nit.	Ash.	Water.	Sp. Gravity.
Wood	39.6	4.8	34.8	0.8	20.	.75
Compressed peat	47.2	4.9	22.9	5.0	20.	1.20
Anthracite	91.3	2.9	2.8	3.0	...	1.40

VALUE OF COKED PEAT.

Early uses of peat charcoal.

In regard to the manufacture of coke from peat, it may be remarked that its value has been known for many years. Thus we learn that as early as 1727 patents were issued in England for the smelting and manufacture of iron with this fuel, and in the Hartz mountains in Germany peat charcoal was used in metallurgical operations on a large scale in 1735, but it is stated that owing the novelty of the process and through the agency of certain parties inter-ed in keeping up the price of wood its use for this purpose was discouraged. ke from simply air-dried peat is found to be too tender for use in the blast rnace, but that from compressed peat was regarded as equally as good for s purpose as that from bituminous coal. The results of its use in the blast rnace are however conflicting as regards its value, this probably being due differences in the quality of the coke employed. From a number of trials de in Ireland it was held that the quality of peat coke was equal to that gas coke, while the total cost according to Vignoles' process, in which the bonization was effected by means of superheated steam, was about two lars per ton (8s. 4d.) with the price of the raw peat at four shillings. ree tons of peat were required to produce a ton of coke, the expense being uced very considerably by the utilization of the bye-products such as wax, , gas, etc.

Tests in Ireland

Probably in no country has the manufacture of peat fuel and charcoal n more successfully carried on than in France, and in the earlier reports of Survey some valuable information will be found as the result of the study of industry by Dr. T. Sterry Hunt at the time of the French exhibition in 55. Among those who have brought the industry to to a high pitch of per-tion may be mentioned Mons. Brughat, and a few extracts from a short nphlet of his on the subject may here be given. After summing up the ious analyses of peat, wood, coal and charcoal he says the calorific power compressed peat made according to the Oballeton process as compared with od and coal is in round numbers as follows :

and in France.

Brughat's analyses.

Compressed peat, varying in value according to process of manufacture and containing 10 per cent. of water, from	3 to 4
Peat charcoal	4½ to 5
Bituminous coal, first quality	5
Anthracite	9½
Wood charcoal	1 to 1¾
Wood containing 25 per cent. water	¾ to 1½

In a special report by Dr. Harrington of McGill University, prepared in 'l in connection with the peat deposits of the Province of Prince Edward nd, assays were made of several of the peat fuels prepared from the bogs t of Montreal. The samples are from air-dried material and the assays are ollows :

Assays by Dr. Harrington of Quebec peats.

	1	2	mean.
Water (hygroscopic)	14.82	15.10	14.96
Volatile combustible matter	60.10	59.10	59.60
Fixed carbon	21.80	22.60	22.20
Ash	3.28	3.20	3.24

The assays of two samples of Hodges peat which had been kept within rs for a year are also given :

	1	2	mean.
Hygroscopic water	16.80	17.32	17.06
Volatile combustible matter	49.80	51.65	50.725
Fixed carbon	26.90	25.00	25.95
Ash	6.50	6.03	6.265

ECONOMIC ASPECT OF THE QUESTION.

The excellent paper published in the last report of the Bureau of Mines, ario, on the subject of peat, sums up very concisely most of the informa-n contained in the several Government reports, and supplements this with a at variety of facts bearing on the general aspect of the question. From it would appear that the most recent tests with locomotives and station-boilers do not give as good results as were anticipated, the percentage of

Recent tests may have been made with peat of

Poor quality and containing an excess of water.

power to cost being very considerably lower than that obtained either from the use of bituminous coal or even wood. This would show conclusively that the quality of the peat employed was far from being what it should be judging from the table just quoted, containing presumably an excess of water greater than should be found even in a first-class air-dried peat. It is probable this peat was obtained from a portion of the bog not representing the best quality for fuel purposes, and thus shows that in the attempt to place this industry on a thoroughly satisfactory commercial basis great care must be exercised in the selection of the raw material. As Brughat has pointed out, repeated failures attended the attempts in this direction for some years both in France and Germany, and it has been only by a careful study of all the conditions not only as regards the material itself but the methods of manufacture that he claimed the success which he has at last attained. It seems difficult to realize the statements as to profit given by Brughat as stated in the report of the Ontario Bureau, but the claim he makes that one and a quarter tons of peat coal are equal to one ton of the best English coal for ordinary steam purposes, and for domestic purposes under proper conditions of draft and grate construction the value is equal ton for ton, deserves a careful consideration of the methods by which these results may be obtained by those interested in the furtherance of the industry in Canada. With coal selling at $3 50 to $4 per ton, which may fairly be assumed as the price paid in Quebec and Ontario in many places for even Nova Scotia slack for boiler use, a compressed peat capable of production at half that price should be profitably employed, while for house purposes where the price of bituminous coal reaches $6 and even in Ottawa $8 per ton, a first-class peat fuel should return very handsome profits to the producer.

Conditions of Brughat's success.

The great extent and apparent value of the peat deposits in this country, together with the very large present consumption of coal and the high prices paid therefor, would appear to warrant the most exhaustive series of experiments tending to solve satisfactorily the economic aspect of the question not only in the production of a fuel suitable in every way for domestic and steam purposes, but for employment also in the reduction of our iron ores and for the various other processes concerned with the manufacture of iron and steel. In this connection we may be permitted to quote again from Brughat:

Importance of careful experiments from an economical point of view.

"It is especially in metallurgical works that very great economy results from the use of our peat. We will obtain among other things both iron and steel of better quality than by the employment of either coal or coke from the use of peat, since the coke therefrom contains no sulphur as has been proved by numerous analyses made with the greatest care, as well as by the practical tests conducted in our forges and blast furnaces both in the manufacture of cast steel, cutlery, gun-barrels and in the casting of other metals."

Cost of production.

In a paper of Prof. N. S. Shaler of Harvard University published in the tenth annual report of the U. S. Geological Survey, on certain fresh water deposits in that country, he remarks on the subject of peat that in his opinion a good peat fuel could be produced at a cost of $5 per ton with labor at $1.50 per day. In view of the results already obtained in the attempts to work the Canadian deposits as quoted in the Geology of Canada, 1863, and from the statements as to cost contained in Brughat's treatise, as well as those obtained from the manufacturers of this fuel in Ireland, we believe that a first-class article can be produced in Canada at a much less figure than he mentions. Such a result however will only be obtained by avoiding the mistakes already so often made by those who have attempted the solution of the problem, and by paying due attention to the quality of the material employed as well as to the use of the best appliances for compressing and preparing for market a fuel containing the least possible percentage of ash and moisture, and in this way obtaining results which will place this material more nearly on a par as regards effectiveness with our best quality of bituminous coals.

Conditions of success in establishing a peat industry.

PEAT AS A FUEL.

By Thomas W. Gibson, Bureau of Mines, Toronto.

Uses of fuel classified.

iel may be roughly classified under four heads :
ourposes, as cooking, heating, etc.
ation of steam for industrial purposes.
ng of ores and refining of metals.
ction of illuminating gas.

Our Sources of Fuel Supply.

es which have hitherto been almost exclusively employed for
Canada as in most other countries are coal and wood, either
condition or in the form of coke and charcoal.

Petroleum.

troleum and petroleum products is not unknown in Ontario,
e furnaces of steam boilers, and recent improvements in the
istion have rendered this fuel of importance where distance
of production does not unduly enhance its cost.

Natural gas.

as also begun to be used and is now in employment on a
manufacturing, domestic and illuminating purposes, but
g for consumption in a foreign country as much as or
n we use ourselves, and the probability is that when we get
e of it in earnest we shall find the supply very much reduced.

Wood.

ery one knows is becoming scarcer every year, and increasing
ts natural result—increased prices. In some country dis-
with which I am acquainted the profusion of wood for fuel
ot long ago existed is now at an end. Of recent years such
as brought a higher price in the log than when cut into
and the consequence is that farmers have sold their maple
ers and their tops and branches only to the users of fuel.
re inferior to the body of the tree both for domestic and
, and in such districts where wood was once the only kind of
t is now a question as between wood and coal, with advantage
ice in some cases in favor of the latter.

Lignite on the Hudson Bay slope.

y we have no coal in Ontario. At least none has yet been
hern portion of the Province, though deposits of lignite are
n the far off valleys of the Moose and Abbitibbi rivers on the
e. The extent and value of these deposits are as yet un-
tematic survey has been made with a view of determining
hey could be made available for economic use, but as they
n the drift it may be doubted whether they are likely to
important supply to the coal-users of southern Ontario. At
e yet far removed from communication and means of trans-
e they ever so valuable they must for the present be left out

Pythonic prospectors who locate coal beds in Silurian rocks.

ne that everybody does not agree with the geologists, that we
al bearing rocks in Ontario. It is natural to argue thus : We
d by Providence so highly in almost every other respect that
nceivable we should have been neglected in the matter of coal.
have heard in past years and still occasionally hear of discover-
g been made in various parts of the Province, such as Colling-
lle and several other points. Some months ago a very valu-
discovered—just to put the geologists to shame—not more
from the city of Toronto, and so precious is the bed to its
have not yet been able to bring themselves to part with any
even to raise it to the surface. No later than this week the
was in receipt of a letter from a man who by means of a
is own construction had located a seam of coal eight feet in

thickness in western Ontario, which upon receipt of a suitable bonus from the Government of the Province he was willing to develop. The advisability of granting such a bonus, I need hardly say, remains under the Government's most serious consideration!

Sources of our coal supplies, and aspects of our situation.

But the lack of coal within our own borders leads to serious consequences. The coal we use comes almost wholly from the mines of Pennsylvania and Ohio, and whenever the gentlemen in control of these mines say "Thumbs up!" on the other side, thumbs have to go up on this side also. Were there even unrestricted competition among the producers of coal in the United States, we could hope to get it in Ontario at the lowest price for which it could be profitably sold, but rings and monopolies govern the production and sale of this important article, and we are thus entirely within the power of foreign corporations who cannot be reached by Canadian laws, and who have "neither bodies to be kicked nor souls to be damned." Nova Scotia, the only other possible source of supply, has unfortunately been shown by experience to be too far removed from our markets to admit of our drawing upon it for any considerable part of our requirements.

In view then of the increasing scarcity and dearness of wood and of our coal supplies being in a foreign land and the subject of an odious monopoly, we are, it seems to me, in presence of a situation which demands our instant and most careful consideration. How are our private and public interests to be protected?

Is there Escape from the Situation?

Will electricity solve the problem?

There are those who hold out the hope of escape from the situation by means of electricity, that force which has already done so much and which is to solve every possible problem of transportation, lighting, heating, smelting and power. Fuel is not required, they say, for the generation of electricity where you have sufficient water power, and in the undeveloped rapids and falls of the upland regions of Ontario where the headwaters of the Muskoka, the Madawaska, the Petawawa, the Bonnechere, the Mattawa, the Severn, the Otonabee, the Trent and many other streams take their rise, not to mention the immense potentiality of the falls of Niagara itself, lies the ultimate solution of the fuel question of Ontario. But while the grass grows the steed starves. There are many and great improvements to be made in the generation, transmission and utilization of electric force before these distant sources of power can be made available for the ordinary purposes of every day life, and some greatly superior means of transmitting electricity through long distances especially is required before that form of force can be expected to supersede for all uses the chemical energy evolved by the oxidation of carbon.

Utilization of peat in older countries.

In older countries, where wood has become scarce and coal for various reasons unavailable, recourse has long been had to peat as fuel, both in the ordinary air-dried form and in a manufactured condition after treatment by various processes. In Ireland, Scotland, Germany, France, Russia, Norway, Sweden and every other European country where peat is found—and it occurs in almost every country lying within the temperate zone—a large proportion of the peasantry have for centuries depended almost entirely upon peat for heating and culinary purposes. I do not need to give any description of the ordinary method of cutting and saving peat, which is practically the same in all lands. It is cut with spades or tools of special form into brick-like blocks, which after sufficient exposure to sun and air become dry enough to burn. This is the method employed where a peat bog can be entered upon and dug with safety and convenience. Where the peat occurs as it sometimes does in a pasty or mud-like mass of little consistency, it is dragged or scraped out to firm land, and upon evaporation of the contained water it forms an article of fuel considered even superior to that produced from an ordinary bog. Air dried peat from a good bog, properly cut and saved, is by no means a despicle article of fuel. There are those indeed who have used it in the old lands 1o do not hesitate to claim for it an equality with either coal or wood. oubtless however one of its principal advantages to the poorer people of 1ropean or other countries is that it can be obtained at an expenditure of tle more than their own labor. A family of growing boys with some assist- ce from the father or even the mother can easily secure a year's fuel at the st of a few days' or weeks' work. The fact that (as in Scotland) where ges have risen and increased facilities of transport have made coal avail- le, the latter is preferred to peat, shows that on the whole common air- ied peat is not to be compared with coal as a fuel.

MANUFACTURE OF PEAT.

Methods of improving peat for fuel.

By various methods of manufacture however the crude article is very eatly improved and brought more nearly upon an equality with coal. The incipal objections to air-dried peat are its bulkiness and the considerable rcentage of water which it retains. One ton of coal is the equiva- nt in evaporative effect of several tons of common air-dried peat, and ordinary ecimens of the latter even when considered dry and fit to use contain not s than 25 or 30 per cent. of water. The object of manufacture is there- re to reduce the peat in point of bulk and to free it from water. One ethod adopted to compass these ends has been tried by means of a great riety of mechanical appliances by inventors on the continent of Europe, in reat Britain and even in the United States. It consists essentially in reduc- g the peat as taken from the bog by grinding, triturating or macerating achinery to a pasty, pulp-like condition, after which it is spread out upon e surface of the ground, marked off into divisions of suitable size and allowed dry. Sometimes the peat is moulded or pressed before being dried, some- mes air-dried before being compressed, and in some methods the drying is one by artificial heat. The result, especially when the drying is hastened artificial means, is a hard dense fuel approaching or equal to coal in speci- gravity, and capable of emitting intense heat. The cost however is con- derable, and though occasionally especially favorable circumstances have con- ired to render the experiment feasible and to enable the manufacture to be ntinued, sooner or later the expense has risen to a point beyond the returns, id failure has been inevitable.

The difficulty to be overcome.

Peat as it exists in the bog contains 90 per cent. and upwards of water, a rge proportion of which it retains with the utmost tenacity, but all or nearly l of which must be got rid of in process of manufacture. To evaporate ght or nine tons of water in order to obtain one ton of fuel would on the ce of it seem an impracticable undertaking, hence various plans have been tempted to overcome this difficulty.

Harrowing.

One is, after the living and (for fuel purposes) worthless growth on top of e bog has been removed and the bog drained, to pass a light harrow over e surface, after which the partially dry peat is collected and the process mpleted.

Pulping.

Compression of the crude peat whether by rollers or powerful presses has so been attempted, but in connection with the pulping process has not proven ry successful, as the pulping is done with much more difficulty and requires uch heavier machinery when the material is in a partially dry state. Indeed ith some stiff, dense peats from the lower portion of deep bogs water has not frequently to be added in order to effect a reduction to the necessary paste- ke condition.

Compressing and drying by artificial heat.

Another system of manufacture is one in which the peat is passed through mpressing machinery at the beginning of the operation, and without being lped or having its original fibre destroyed is dried by artificial heat and strong pressure formed into blocks, cakes or cylinders of the desired size. ne employment of artificial heat of course adds to the cost of the process, but it is doubted by some whether the water contained in the peat can be wholly expelled or even eliminated to the required extent by pressure alone, and experience appears to bear out this view.

Improvement by charring or coking.

Peat is used not only in its ordinary form, but like wood and coal may be carbonized and reduced to coke or charcoal. Containing a percentage of carbon in proportion to its weight intermediate between that of wood and coal, it gives on carbonization a corresponding weight of charcoal. Wood yields about 22 to 27 per cent. of charcoal and coal 75 to 90 per cent., while peat gives about 23 to 35 per cent The condensed peat produced by the pulping process gives a much harder and denser charcoal than the ordinary air-dried article, the charcoal from which is so friable and light that it cannot be used in metallurgical operations. Peat charcoal has this advantage in common with wood charcoal over coke from coal, that it is much freer from impurities, such as sulphur and phosphorus, which exercise so injurious an effect in the smelting or refining of iron. These and other impurities however are not unknown in peat, and their absence or presence is usually dependent upon the constituents of the rocks and soil surrounding the bog from which the peat is taken. The decomposition of gypsiferous or pyritous rocks in the neighborhood of a peat bog would, for example, be sufficient to account for the presence of sulphur in the ashes of peat fuel manufactured from it. A bog in Wales containing copper pyrites was long used for the production of peat which was burned for the sake of the resulting ashes, many thousands of pounds' worth of copper having been extracted therefrom. Peat usually yields more ash from a corresponding weight than wood and about the same as coal, but it varies greatly in this respect with the composition of the bog from which it is taken. Sand, lime and other similar substances are generally found in the ashes of peat, either in chemical combination or mechanical mixture, having in most cases been derived from the surrounding soil.

Processes Under Way.

Slow progress in the manufacture of peat.

The Hodges,

Aubin-Hally, Aikman and

Dickson processes.

As might have been expected, much more effort has been made to produce a good article of peat fuel economically in European countries than in the United States, where there is a comparative abundance of coal. In the latter country about twenty-five or thirty years ago coal was even higher in price than it is at present, and much attention was directed to the utilization of peat, without however any lasting result. In Canada on the other hand the fuel problem has been more pressing, and at various periods processes have been in actual operation for the manufacture of peat fuel for a longer or shorter time. Recent events seem to indicate a revival of the interest in this question, for at the present moment there are three or four processes under way by which their inventors hope to solve the perplexing problem. In the neighborhood of Montreal and elsewhere in the Province of Quebec probably more persistent attempts have been made in this direction than anywhere else in Canada. Nearly thirty years ago Hodges placed his pulping machinery on a scow and manufactured peat at Bulstrode, at we are informed a cost of 92 cents per ton, and large quantities were consumed as fuel for the locomotive engines of the Grand Trunk railway. A somewhat similar process invented by N. Aubin and improved by James Hally was at work for a time under the management of the Valleyfield Peat Company, while David Aikman of Montreal for many years has been experimenting and is still experimenting with the process of manufacture which bears his name. A. A. Dickson of the same city has invented a process somewhat different in principle from any of these, which he believes is now perfected, and which the company he has formed intend to have in operation this coming summer in a bog on the Welland canal, where they have purchased a tract 3,000 acres in extent. I have here specimens of Aikman's, Hally's and Dickson's peat fuels, as well as samples taken by myself from a small bog near Berlin, Ontario. The last named le is of the ordinary air-dried kind, and being taken from the bottom he bog shows the deposit of shell marl underlying the bed of peat. imens of Aikman's and Dickson's manufacture corresponding to these have submitted to Prof. Ellis of the School of Practical Science, Toronto, for nination. He has tested them in a Thompson calorimeter with the fol- ng result:

A calorimeter test of manufactured peats,

	Aikman peat.	Dickson peat.
Moisture..........	7.4	10.2
Ash..................	19.5	2.9
Heating Power	5115 units.	5280 units.

hree samples of standard kinds of bituminous coal were also submitted rof. Ellis for purposes of comparison, which gave in heating power as ws:

and bituminous coal.

	Units.
Hocking coal, Ohio..................................	6,820.
Masillon coal, Ohio..................................	7,425.
Reynoldsville coal, Pennsylvania.....................	7,480.
	Mean—7,241.

heating power is expressed in metric heat units.

t will be seen that the two specimens of peat are nearly alike in heating er, and that in this respect they stand respectively in the relation of 71 73 per cent. of the mean value of the samples of coal. The average price eynoldsville coal at Toronto, where it is said to have control of the mar- or heating purposes, is $4.25 per ton, so that on the basis of calorific e alone these peats would appear to be worth about $3 or $3.10 per ton. percentage of moisture does not materially differ in the two samples, 7.4 and 10.2 respectively, and it is probable that experience would the inutility of going to the trouble and expense of reducing the con- d water below the smaller of those figures, as on exposure to the atmos- e the absorbent qualities of the peat would doubtless be sufficient to re the percentage of water to at least this point. The greatest differ- between the samples is in the matter of ash, in respect of which there is rked inequality, one sample showing 19.5 and the other 2.9 per cent. is of course due entirely to the composition of the bogs from which samples were made, and has no bearing upon the merits of the esses of manufacture themselves. If the crude peat contain a con- able proportion of incombustible matter no amount of trituration, com- ion or other subsequent treatment will lessen it, and the plain inference at in the manufacture of peat fuel only those bogs should be employed h careful experiment shows to be reasonably free from inorganic sub- es. The proportion of ash contained in the more impure of the two les, 19.5, is so high as to seriously detract from its value as fuel, and d lead to the conclusion that the bog from which it was made is not well d for the manfacture of the article.

Comparative merits.

Ash.

PEAT FUEL FOR METALLURGICAL OPERATIONS.

recent letter from England gives an account of a process by which Mr. . Brunton of London is attempting to utilize the peat of Dartmoor in production of pig iron from hematite ore, of which abundant supplies in that district. He proposes to use by a happy reciprocity the waste s from the blast furnaces to dry the peat, and the peat, apparently with- eing charred, to smelt the iron. It is estimated that 200 tons of peat suffice for a yield of 100 tons of pig iron per week. The cost of iron ore t at from 3s. to 6s. 6d. per ton, and the cost of the pig iron made under conditions after ample allowance for contingencies at £2 15s. per ton. e selling price of the iron be put at only £5 per ton (a low price for oal iron) a profit of £2 5s. is expected to be realized. A square mile of Dartmoor peat ground is said to be sufficient to supply fuel for a make of tons of pig iron per week for 100 years.

A new English process of manufacturing peat for blast furnace fuel.

Peat kilns in Europe.

The application of the hot gaseous products of blast and other furnaces to the dessication of peat is not however original with Mr. Brunton. On the continent of Europe kilns for drying peat have been constructed in which the hot waste-gas of furnaces is driven in through the roof by means of a fan, made to descend through the peat, and thence to pass into a chimney communicating with the interior of the kiln at the bottom by two flues, one on each side. Kilns on this principle are said to have been first introduced by Schlägel into Austrian smelting-works, and extensively adopted, especially in French smelting-works. The distinguished Swedish iron master Gustav Ekman in 1856 erected a peat kiln upon this principle with, it is reported, an entirely favorable result. Ekman heated his kiln with the waste gas of a charcoal finery, which gas after having been used for heating pig iron, the blast of the finery and an annealing furnace, was admitted into the kiln. Kilns constructed on the principle of taking in the hot gas at the top are said to dry the peat more equally and quickly than those in which the gas enters at the bottom.

Utility of peat fuel in metallurgical operations.

Peat and peat charcoal are used to some extent in the smelting and refining of iron in European countries, but where, as in Great Britain, mineral coal and coke are abundant the latter are more generally employed. Dr. Percy, after a somewhat exhaustive review of the subject in his work on Fuel, gives it as his opinion that "by a judicious selection of peat and suitable treatment peat charcoal might, so far as relates to its capability of producing heat, serve as an efficient fuel for metallurgical operations." He adds that "the use of peat charcoal for fuel must in great measure depend upon the cost of its production, inclusive of the cost of the original peat, and its capability of competing in that respect with other fuel, namely, wood-charcoal, certain kinds of coal and coke." The widest field of usefulness for peat in metallurgical processes would appear to be as material for the production of gas for use in the so-called regenerative furnace invented by the brothers Siemens, which has come so largely into use for smelting and refining purposes. To quote Percy again: "Experience on the continent has conclusively shown that peat-charcoal may be used in some metallurgical operations with success; also that peat may be successfully used for the production of gaseous fuel in a gas-producer. Mr. C. W. Siemens indeed has informed me that putting its cost aside he should even *prefer* peat to coal for use in the producers of the regenerative gas-furnace. Now the metallurgical operations to which gaseous fuel has been applied are already numerous, and it seems capable of even much wider application. The drawback in the employment of peat when high temperatures are required, resulting from its containing a large quantity of water, is obviated by converting it into gaseous fuel, and subsequently condensing the moisture contained in the latter. So far therefore as the suitability of peat for metallurgical purposes is concerned, we may not unreasonably conclude that it could be widely substituted for coal with success." Percy goes on to state his conviction that peat can only compete with coal in countries where the cost of production and carriage of peat is relatively very low and the price of coal relatively very high, and that as regards Great Britain circumstances must greatly change before these favorable conditions for utilizing peat are fulfilled.

The situation in Ontario and Quebec.

Percy's conviction as regards Great Britain is doubtless well founded, but the state of things in Ontario and Quebec is vastly different from that in the mother land. The pregnant fact that while there is abundance of coal in England there is none at all here changes the situation entirely, and conclusions which may be justly arrived at in the case of Great Britain are altogether inapplicable in our own. The cost of carriage which in England would be greater upon peat than coal is here decidedly in favor of peat. Our only supplies of coal lying either a long way to the south in another country, or a long way to the east in another Province, the item of freight arges must always be a heavy one and must continue to add largely to the st of the coal used here, while on the other hand once a really practical d economic system of manufacture was introduced the peat bogs which e found in all quarters of Ontario and Quebec might be made sources of el supply to surrounding districts at a minimum cost so far as freight arges are concerned.

PEAT AREAS IN ONTARIO.

There are very large areas of peat in Ontario. Mr. E B. Borron, who s penetrated through the wastes of the Hudson Bay slope, tells us that in s opinion there are 10,000 square miles overlaid with peat from six to enty feet in depth in that part of the province. In the district between e Ottawa and the St. Lawrence rivers, in the vicinity of lake St. Clair, in gin county, in Parry Sound district, in Waterloo county, in Welland unty along the Welland canal, in the counties of York and Simcoe, along e line of the Canadian Pacific Railway west of lake Nipissing, and in many her sections of the Province are peat bogs of large area, and were they to come valuable as a result of a perfected process of manufacturing peat fuel e existence of many others would no doubt be revealed.

Localities where peat deposits are found in great abundance.

A storehouse of great value

Peat fuel has been successfully employed for all the purposes for which al and wood can be used. For some of these purposes it is, owing to its lk, less adapted than coal, as for instance in steamer and locomotive ilers, where economy of space is a great object, while for others, as we have en, it is a very efficient substitute. Even in the production of illuminating s it has been employed with good results, as for example in Dartmoor, ngland, where the prison at Prince Town is or was lighted with gas made om peat.

In conclusion, I have only to express my conviction that this problem of e utilization of peat for fuel is one of the most important and pressing of e economic questions which are today engaging the attention of the people Ontario and Quebec. Though the difficulties which lie in the way of its lution have proven themselves to be many and formidable, the ingenuity of an is, I am convinced, equal to the task of overcoming them. I cannot ink that the quest after a good cheap peat fuel is the chase of an *ignis tuus*, but on the contrary I cherish the hope that ere long we shall see a ocess in successful operation which will utilize our own resources, give us a st-class fuel at a cost below that of coal, and deliver us from the yoke of a reign monopoly.

when the problem of treatment is solved.

DISCUSSION ON THE PAPERS.

Discussion upon the papers was invited, and Mr. A. A. Dickson, who as present, and whose method of manufacturing compressed peat fuel was escribed in the Report of the Bureau of Mines for 1891, was asked to speak.

Mr. Dickson said he had little to add to what had already been said, cept to say that the company which he had organized had secured a bog on e Welland canal about 3,000 acres in extent, and were having the necesry plant constructed for manufacturing the fuel. The blocks which had een exhibited as of his manufacture were merely small samples. It was e intention of the company to make the fuel in at least two sizes, one in locks about 3 inches long and 3 inches in diameter for steam generating urposes, and the other for domestic use in blocks about 2 inches in iameter. In his process as perfected the moisture is driven off solely y compression, artificial heat not being required, and not more than 10 er cent. of water is left in the manufactured article. They found the quality of e peat in the Welland bog to be excellent, and the upper portion after e moss is removed to be nearly as good for fuel purposes as the lower, e samples shown having been made from it.

Erecting works to manufacture peat fuel on the Welland canal.

Mr. B. T. A. Bell asked Mr. Dickson at what price he thought he could place his fuel on the market.

Mr. Dickson replied that it would have to be sold at a lower figure than coal. The cost of manufacturing would be about $1.50 per ton.

Resistance to moisture.

Mr. Th. Doucet inquired whether samples of Mr. Dickson's peat such as those exhibited had ever been subjected to water, and with what result.

Mr. Dickson said the peat was proof against moisture under ordinary circumstances, but if immersed in water for some time it would absorb a certain percentage. The samples shown were made from the Champlain bog, in Quebec.[1]

Mr. Doucet wished to know if the samples of Hally peat shown by Mr. Gibson had been subjected to compression.

Mr. Gibson : No, it has simply been pulped and dried by evaporation in the open air.

Peat in Prince Edward Island.

Prof. Harrington (McGill College) stated he had had some experience with peat some years ago. The best peat he had ever seen came from Prince Edward Island, where there are large deposits along the seashore from which the peat could be loaded directly into schooners. They had been told that great care must be exercised in selecting the material, and this was a very important point. Many of the peats which had passed through his hands had not been chosen with sufficient care, having run too high in ash. The suitability of peat for smelting purposes had also been spoken of, and it was sometimes alleged that iron could be made with it better than with coal. He had always understood that while free from sulphur the ash of peat was frequently high in phosphorus, which would be a serious objection to its use in smelting iron. He had no definite statistics on the point however, and it would be an interesting one to investigate. It was also to be borne in mind that if peat were made into coke a large quantity of volatile matter would be driven off, and a peat that gave say 5 per cent. of ash would yield a coke containing perhaps 15 per cent. of ash, which again showed the necessity for a careful selection of material to be treated.

Care in selection of material.

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[1] Mr. Dickson furnishes the following particulars of a comparative test of his fuel and anthracite coal made at the John Abell engine works, Toronto :

Dickson's compressed peat, weight 457½ lb.; date of test, 13th December, 1892. Temperature in boiler house, 69°, outside, 39°, of feed-water, 122°; weather dull. At 1.34 the first peat was put in with a full fire of red coal, say 6 inches deep on the grates. Steam at 85 lb. pressure, with 9 inches of water in the gauge-glass. In six minutes the steam rose to 86 lb., at which point it remained for three minutes; it was then kept steadily at 85 lb. during the whole time of the test, the pointer only vibrating sufficiently to show the line on each side alternately. At 3.34 the steam pressure began to go down, when firing was resumed with the regular fuel. Immediately before commencing the test the boiler-tubes, ashpit and furnace were cleaned out. At the conclusion of the test the water stood at 9 inches in the glass, where it had been kept without varying during the whole of the time. Duration of test, 2 hours.

Large anthracite coal (egg), weight, 457½ lb. Date of test, 15th December, 1892. Temperature in boiler-house, 82°, outside, 31°, of feed-water, 121°; weather bright and sun shining. At 1.40 commenced firing with the test fuel with 9 inches of water in the gauge-glass. Steam at 85 lb., the fire, as nearly as could be judged, being the same as in the previous test. The steam remained steady at this pressure, with no more variation than that recorded in the other test, until 3.46½, when it began to go down, and firing with the usual fuel was resumed. At the conclusion of the test the water stood at 9 inches in the glass, being kept there steadily the whole time. As in the test with peat, the grates, boiler-tubes and ashpit had been cleaned out. The work on the engine was the same in both cases. Duration of test, 2 hours 6½ minutes.

Commenting upon these experiments, Mr. Dickson says : The test was made on a coal-burning grate, which is not quite suitable for the burning of peat, inasmuch as the surface is entirely too large. The temperature of the boiler-house when the peat was used stood at 69° above zero; when the coal was used it stood at 82° above, making a difference in favor of coal of 13 degrees. When the peat was used the weather was dull; when the coal was used the weather was bright and the sun was shining—a very material difference in favor of the coal, as those familiar with steam know. Notwithstanding this, 457½ lb. of compressed peat kept the steam steadily at 85 lb. for exactly two hours, while an equal weight of coal kept up the same pressure for only six and one-half minutes longer. Under similar conditions as to temperature and with a proper type of grate, peat would have done as well as the anthracite coal, if not better.

PEAT IN EUROPE TODAY.

Probably the most recent information obtainable as to the uses of peat in
various countries of continental Europe at the present time is to be found
the consular reports made to Her Majesty's Government on the subject
l laid before both Houses of Parliament in March, 1893. These reports
re made in pursuance of instructions given by Lord Salisbury to Her
jesty's representatives at The Hague, St. Petersburg, Stockholm, Copen-
gen, Berlin and Paris to forward such information as they might be able to
cure with regard to the manufacture of fuel, moss litter and other products
m peat in the various countries to which they were accredited. These
orts show in general that peat is still an important article of fuel in those
ts of Europe where, owing to lack of coal, distance from seaports or prox-
ty to peatbogs, it can be obtained at a less cost than coal. Other uses of
t and peat products, particularly as moss litter and in the conversion of
vage products, are also becoming more and more important, and in view of
comparative cheapness of coal in many parts of Europe it is probable that
utilization of peat will develop more rapidly there for such purposes than
that of fuel only. Moss litter is being manufactured in nearly every
ntry in Europe. It is coming rapidly into favor as material for bedding
ses, cattle, etc., one great recommendation being its capacity of absorbing
isture to many times its own weight. Considerable quantities are exported
m Europe to Great Britain and also to the United States.

British consular reports on uses of peat

DENMARK.

Sir H. G. Macdonell reports that all the different modes invented during
past forty years for the treatment of peat have been tried in Denmark, and
e been given up as impracticable, unprofitable, or both. Expensive experi-
nts have been carried on at Silkeborg and Moseland within recent years, but
h no appreciable results. In fact peat may be said to be used merely for
l, the people cutting sufficient for their own consumption. In some of the
nd towns in close proximity to larger moors there still exists a certain
nand for peat, but at seaports it seems never to have been able to compete
h coal, the specific heating power being too low as compared with that of
l to enable the peat to pay expenses connected with transport to any dis-
ce. Peat for fuel is either simply cut and dried, undergoing no further
atment ('skoretorv') or it is kneaded together, and subsequently cut into
ular shapes for fuel, called 'oltetorv.' In this latter shape, as in the
mer, it does not pay the cost of transport to any distance. To the north
the Limfjord at Lundergaard Mose, the Aalborg Mosstroelsefabrik formerly
ployed some fifty to seventy men in cutting peat, which was used by the
lway authorities for heating their carriages. This method of heating hav-
now given place to steam, the occupation has ceased, and a moss litter
tory has taken its place.

All invented modes of treatment abandoned.

Moss litter and

The following account is given of the way in which moss litter is used in
stables of the Copenhagen Milk Supply Company:

"Each stall is constructed with a hollow lined with cement three inches
p below the level of the floor paving. This is filled with the litter. About
inch in depth is removed daily from the surface, the fresh supply being
d at the manger end, while the supply of the day before is raked from the
ad to the hinder end. The litter so removed forms most excellent manure.
e peat-moss litter is delivered in compressed bales of 150 lb. each, and care
st be taken that it should be almost free from any moisture in order that
may be able better to absorb all moisture when in use. The company in
estion keep fifty horses. Though it is customary in Denmark to take but
tle care in grooming horses and keeping stables clean, and though there is
drain whatever in the stable in question, no trace of ammonia and hardly
y unpleasant smell could be detected. The manager, Herr Busck, informed

me that the litter for the fifty horses cost the company £100 a year, or £2 a horse per annum. The use of this article, for sanitary and economical reasons, in large towns and for cavalry barracks, cannot be overestimated, and since the same quality of peat exists in Great Britain, this industry should certainly be capable of great development."

Its commercial and sanitary values.

FRANCE.

The Marquis of Dufferin reports briefly that it appears the peat industry does not exist to any appreciable extent in the consular districts of Brest and Cherbourg; a small quantity of peat is cut for the purposes of fuel, and in that of Marseilles turf is also used for burning in the neighborhood of Lyons, but there appears to be no appreciable commerce. In the district of Calais, again, it is reported that there is no manufacture of moss litter from peat, while the quantity cut by the peasantry has been for many years on the decrease, and in 1890 573 cubic metres only were cut at Condette and in the district of Montreuil, some 5,000 cubic metres in seventeen communes, while though there are peat bogs in the Department of the Nord, no turf was cut in 1889 or in 1890. A small quantity is also cut in the Department of the Somme As regards southwestern France, Mr. Consul Ward reports that there are peat bogs of more or less limited extent in all the Departments forming the consular district of Bordeaux from which peat is extracted for fuel, but the production is confined to local consumption. In the district of the Charente some 7,000 tons are cut annually, but the amount is far less than in former times. But the only use to which the peat is applied on the spot is for fuel. The Bordeaux Tramway Company, which tried the experiment of peat moss for litter, has now abandoned the use of it, partly because of the difficulty of disposing of the manure, and partly because the litter, which was sold to them by weight, was frequently supplied in a damp condition, which considerably reduced its utility. In Paris there are four or five firms which supply peat for fuel. There is however one important enterprise, the company known as La Beraudine, founded by M. Beraud for working his patents and manufacturing a number of articles from peat fibre, including litter, disinfecting media, blankets, carpets and rugs, mattresses, antiseptic food, preserving material, manure, etc.

Small quantities produced,

and are confined to local consumption.

Manufactures from peat fibre.

In a supplementary note it is added that this Company supplies about eight different articles to the French Government, chiefly mattresses, blankets, saddle-cloths, etc., but that the number of articles manufactured from the fibre obtained by M. Beraud's process is very great, and comprises nearly all those in which felt has hitherto been used, with this important difference, that the articles are made from a woven fabric and not from a brittle material like felt.

GERMANY.

Sir E. Malet forwards a report containing much information, from which the following extracts are made:

The area covered by peat bogs ('torfmoore') in Germany is very extensive, especially in the northern provinces of Prussia and the grand duchy of Oldenburg, but a small part only of this area is Government property, and no statistics of any sort are available as to the actual acreage and production. Almost all these moors are worked locally for fuel peat, and the manufacture of moss litter is also very widely spread, being carried on in East Prussia, Pomerania, Posen, Silesia, Hanover, Oldenburg, Wurtemberg, Saxony and Bavaria. The peat bogs belonging to state domains in Prussia, of which a larger number exist, are generally worked by the Government Forest Department; many of them however are let for a term of years to private individuals, the lease being usually made out for thirty years or more, and the tenant having the right and in some cases assum-

Peat bogs worked for fuel and moss litter.

the obligation of removing all the peat during that time, thus pre-
ng the land for agricultural development. An important moor under
e management, and within a short distance of Berlin, is that of Caro-
nhorst, near Stettin. It covers an area of about 2,000 acres, and is
inistered by the Finance Department of the Government of Stettin.
n in this case however although the peat cut for fuel is sold by the
e authorities, the manufactory of moss litter is let to a private *entre-*
eur. A notable private undertaking of the kind is that of Herr Rott-
h at Gifhorn in the Province of Hanover, where both peat fuel and
litter are produced on an extensive scale. . . . The principal
lucts obtained from peat are:—(1) Fuel, including turf coal and turf
. (2) Moss litter. (3) Peat dust ('torfmull') for disinfecting purposes.
Coarse textile fabrics, paper and various chemical products.

Peat used for fuel chiefly near the place of production.

The use of peat as fuel is universal in the neighborhood of the moors, but
enerally local. It cannot compete with coal for cheapness in any dis-
s near the seaports or near towns which have railway communication.
for fuel cannot pay railway freight for more than twenty miles from the
e where it is cut, and very little is ever conveyed by rail. The rate
ged is about 9s. per load of 9,600 sods of peat for 10 miles. There are
vailable statistics either in Prussia or the other peat-producing states as
ie amount consumed, but considering the wide distribution of peat bogs
ughout the country it is probably very great. It is estimated, for
nce, that in the grand duchy of Oldenburg alone about 150,000 tons of
are burnt per annum, chiefly for household purposes, but also in baking
s, brick-kilns, etc. . . . No machines are used on the Government
rs in Pomerania for cutting fuel peat, but they have been employed on
ate moors where labor is scarce. The cost of production is not sensibly
ced by machine-cutting. The best peat for burning is generally that
h lies undermost, the upper layer, to a depth of 4 ft. 6 in., being used
re it is of suitable quality) for moss litter; all beneath that depth for
ing. At Carolinenhorst the peat is always dried in the open air, all
r methods having proved too expensive. An attempt was made at Gif-
to dry the peat artificially in an apparatus invented by Herr Rottbarth,
as the system was abandoned after a very short trial it appears not to
been a success. . . . . The first class is the dark peat, approach-
o coal, which is usually cut from the lowest stratum, and is heaviest.
rinks most in the process of drying, a fresh sod measuring when cut 13
es in length by 10 inches high and broad. This class of peat burns
ly, and when fifteen sods are burned in a closed stove they will leave
t a large wineglass full of white ash. The second class is lighter in color
weight, and is a newer formation. The third class is the top stratum,
is of least value except in those cases where it is suitable for the manu-
re of moss litter. These lower classes of peat leave more ash in burn-
In some places these differences in the quality of the peat taken from
op or the bottom of the stratum do not occur, the moss being uniform
ghout. The peat is sold by auction (at Carolinenhorst) and fetches as
e: 1st class, 14s. per 'klafter' of 1,200 sods, 2nd class 10s., 3rd class 8s.
moor at Carolinenhorst employs about 500 men and women for cutting
stacking peat, chiefly for fuel. The average amount earned by a man
is work is from 4s. to 4s. 6d. per day, but they are paid according to the
int cut. The women are paid about 3½d. for every cubic metre stacked.
. . The best material for the production of moss litter is formed by
ipper strata of the 'hochmoore' (high bogs) which cover considerable areas
anover, Oldenburg, East and West Prussia and Pomerania. The natural
tation of these bogs consists of moss, together with various grasses
heather (Eriphorum, Calluna vulgaris, Erica tetralix, Andromeda,
im, Empetrum, Vaccinium and Sphagnum cymbifolium). The decom-

Qualities peat.

Employment of labor.

Best material for litter.

posed remains of these plants form a dark soil overlying the yellowish-brown layers of moss peat which often attain a thickness of several yards, and in their turn overlie the older and darker peat which is used as fuel. The characteristic of the strata suitable for the production of moss litter is that in them the process of decomposition is incomplete, and that they form an extremely porous and elastic substance, which is capable of absorbing water like a sponge. In the process of drying this material contracts very little, and consequently remains soft and elastic. . .

Process of manufacturing litter.

The outlines of Hollman's system of manufacturing moss litter are briefly as follows: The moss peat is cut out of the bog in sods in precisely the same manner as fuel peat. The autumn and early winter are chosen for this work so as to allow the moss peat to freeze before drying. It is dried in stacks in the open air. At Carolinenhorst about 6½ acres, 58 inches deep, are cut each season, and yield about 3,000 tons of moss litter. The sods when dry are taken to the factory, placed in elevators and carried to a machine called the 'wolf,' which tears them into small fragments. The moss thus produced is passed over sieves to separate the peat dust ('mull') from the fibrous substance which forms the litter. It is then brought into a press which (in the case of Carolinenhorst) is 10 feet high by 2½ feet square. The pressure employed is about four horse power, and six cubic feet of the loose material are pressed into a space of two cubic feet, being then baled with six to ten laths of wood and bound round with iron wire. It is then ready for the market, and is valued at 1s. per cwt. at the railway station. The moss litter factory on the Carolinenhorst moor employs fourteen to sixteen hands, of whom one-third are women, the working day being ten hours. An adult workman is paid about 2½d. per hour, a young man 2d., and a woman 1½d

Merits of the litter,

. . . It is claimed for moss litter that (1) it affords drier and healthier bedding for horses and cattle than any other material, (2) that in consequence of its great power of absorbing moisture it binds the valuable portion of the animal excrements and consequently yields the best manure, (3) that it acts as a disinfectant and improves the air of the stable, (4) that a smaller quantity of it is required than would be needed if straw were used. The published results of experiments and longer experience in the use of moss litter are not entirely consistent. In general however they are favorable, especially where horses and horned cattle are concerned; and cases of sickness consequent upon its use can be traced as a rule to negligence or the use of damp litter. The following is an extract of a report on the use of moss litter in the stables of the Prussian regiment of Uhlans (Lancers) No. 14, which seems entirely favorable: The regiment has used moss litter as a substitute for straw with the object of obtaining better and drier beds for the horses and reserving the fresh straw for food. This object was attained with complete success. For experimental reasons the horses were not all placed on moss litter at once. In October one-third were placed on moss litter. In November two-thirds were placed on moss litter. In December nearly all were placed on moss litter. The following advantages were observed: Dry beds and dry fresh air free from ammonia; the ceilings, walls and leather trappings remained free from moisture and mould. Moss litter absorbs eight times its own weight of urine, whereas straw absorbs only three times its own weight. The short and broken nature of the moss fibre allows of the easy removal of the wet portions. Care must be taken not to neglect to turn and shake up the litter every day and to fork it from one part of the stall to another. If these precautions are observed the animals find a dry bed, the horses remain clean and their skin in activity. If properly treated, moss litter is far more elastic than straw and affords a more comfortable bedding. The harness and saddles, as well as the boots of our soldiers are better preserved. From a veterinary point of view further advantages are observed. Catarrhs of the nose and eyes, generally the result

as shown by practical test.

bad air in the stables, are less frequent; wounds on the legs heal quicker;
flammation of the glands very seldom occurs, and rotting of the frog is
most entirely prevented. In cases of contagious diseases moss litter is of
eat value and surpasses all other disinfectants.

The smaller particles which are separated from moss peat when it passes
rough the 'wolf' and the sieves used in the manufacture of moss litter, are
llected and reduced to a powder known as 'torfmull.' This product has
tained a market for various purposes, and sells at about 1s. 3d. per cwt.
is used, according to the report, as a disinfectant, as a material for making
tiseptic bandages, in absorbing the lye resulting from the treatment of
lasses with strontium in sugar factories, as an admixture with salts used
powder as chemical manure, and as packing material for breakable or
rishable goods.

Uses of peat in industrial enterprises.

Apart from the use of peat as fuel and in the shape of moss litter, its
ployment as raw material in other branches of industrial enterprise is
its infancy. Its utilization has been attempted in the following ways: A
ostance consisting of a mixture of peat dust, India-rubber, and sulphur
s been found to be excellent material for isolating subterranean electric
les. Good porous bricks are manufactured at small expense by mixing the
y with peat dust. Pure moss-peat mull, free from admixture of grass peat
particles of sand, has been used for some time in the manufacture of
powder to replace charcoal. Peat fibre carefully freed from dust is begin-
g to be used as a material for carpets and other coarse textile fabrics. The
e is also used as raw material in some paper-mills and manufactories of
uloid. The chemical industries are likewise attempting to make use of this
mising material, and gas for lighting purposes, tar, parraffin, solar oil,
togen, etc., have been manufactured from it. Matches have also been made
peat fibre instead of wood.

THE NETHERLANDS.

Curing of dredged turf.

Mr. Consul Turing of Rotterdam gives an account of the manner in which
so-called short or dredged turf is produced on the low-level moors. This is
ained by dredging with a kind of scoop, when a black and soft substance
rought forth which is spread out to a depth of five to six inches on a
ring of boards, and is then trodden down by laborers with specially
pted wooden shoes with the object of obtaining one adhesive mass. This
bsequently cut through crossways with a spade, each portion having the
n of a turf, and the whole mass is then left exposed to wind and weather
il the turfs have arrived at a sufficiently dry and hard state to allow of
r being handled, when they are stacked in long rows to a height of 2 to 3
. The exposure to the sun and wind results in their drying up entirely
attaining the necessary hardness. They are then collected and stacked
arge heaps with a covering of reeds, and are subsequently brought to
ket. This kind of turf is exclusively used for domestic purposes. Num-
of skippers with their barges proceed throughout the year to the moors
he northern provinces, where they buy the turf for subsequent retail sale
he towns and villages.

The production of peat moss has been carried on in the Netherlands for
about ten years, and in no other country has it assumed such dimen-
s. It is produced on the high-level moors, the upper portion of the bog or
turf being used for the purpose.

Mixing 'fine' peat with sewage for manure.

'The 'fine' litter is used for mixing with sewage, and a mixture of equal
ntities produces a dry, dark, earthy substance, which can be turned over
a spade and is entirely inodorous. As a manure this product is quite as
able as the stable moss litter; but whilst the latter in its original state is
nsively used in all European countries and also in America, the mixture
fine' peat with sewage is but little known, although in some cities such as

Bremen, Brunswick and Oldenburg the product is largely used by the authorities. In Gothenburg, in Sweden, the 'fine' peat has been utilized for a number of years, whilst in Belgium a company has been formed for the purpose of collecting the sewage of the several towns and mixing it with moss litter and thus producing a merchantable article. Initiatory steps have been taken in Bruges and Mons, and the company will soon commence in other towns. Although the special advantages attaching to the mixture of the litter and sewage appear to be so little recognized as yet, nevertheless we think that through this industry the gray turf moors have a great future before them. In 1889 the value of one hectare (fully 2 acres) of this kind of moor was £100, whilst only ten years previously the gray turf being considered valueless, was ruthlessly cut up and thrown away, the only object being to get at the sub-strata of black turf."

Factory turf as fuel for firing brick kilns.

We now come to the subject of black turf, or as it is usually called by the trade factory turf, from its being almost exclusively used in the brick kilns along the rivers Maas, Waal, Linge, Lek and Yssel. This turf is dug up in the same manner as the gray, but care must be taken to dig only when there is no fear of frost, and also to stop digging in time to allow the turf to be quite dry before the frost sets in. The period for digging the black turf lasts therefore only from the 15th March to 15th June, whilst the gray can be worked throughout the whole year except when the soil is too hard through frost. If black turf is frozen before having dried it loses its heating power and consequently its value as a merchantable article, and then it is sold at a very low price for domestic purposes. The factory turf is conveyed in barges to the brick kilns. The importance of the trade in this article may be gathered from the fact that in the Netherlands about 280,000 tons weight are annually consumed in the manufacture of bricks, of a value of £133,000, of which £100,000 represents labor and freight. The value of one hectare good and favorably situated black peat may safely be taken at £170.

Natural turf.

Mr. Consul Robinson of Amsterdam speaks of the natural turf which has undergone no preparation save cutting from the bog and drying in the air, as having all the inconvenience and undesirability of a spongy fuel and as being unpopular as such. Hand labor is used in cutting where the bog has already been well drained. Where this is not the case cutting machines have to be used, one of the best known of which is the Victoria turf cutter manufactured by Brosowsky of Stettin, Grunhof. The natural turf is much inferior to the machine-made article, the substance of which is densified by various processes.

Pressed, washed and sifted turfs.

"The turf mass is either first disintegrated and dried in ovens and then pressed into moulds, or treated by the wet press process fresh from the peat bog (Koch and Mannhardt's system), and in this way pressed turf is obtained. Washed turf is produced by the Challeton system by passing the raw peat through rollers with knives; it is then driven by means of brushes through a fine sieve and then mixed with water, forming a pulp which is placed in casks in which the mineral and earthy parts sink to the bottom. The pulp is then dried in pans, and when sufficiently compact moulded in shapes. Sifted turf (Versmann's system) is obtained by placing the raw peat in an iron disintegrator, through which runs an axle with a serpentine knife. The finely-cut peat is squeezed out of the disintegrator through small holes, while the coarser parts pass through the bottom opening of the disintegrators. The expression 'machine-made turf' includes all those descriptions of turf in manufacturing which the fibre of the peat is cut by machinery and remixed in such a manner as to form as far as possible a homogeneous product, even where turf presses for condensing the same are not used. It may be assumed that nine cubic metres of fresh peat will produce six cubic metres of wet machine made turf, that is seven (?) cubic metres of dry machine-made turf weighing 200 kilog. The specific gravity of air-dried, hand-cut urf is on an average .2, that of the air-dried machine-made turf .6 o 1.3, according to the quality of the raw material. Air-dried machine-made urf contains up to 30 per cent. of water, and as this must be evaporated luring combustion there is a considerable loss of heating power. In order to essen this, drying ovens of various construction have been tried. Turf is lso converted into charcoal in the same manner as wood, both in heaps and pecially constructed ovens. Turf charcoal is nearly equal to wood charcoal n heating effect, but is not so useful as the latter, as on account of its porous ature and proportionately large residuum of ash the fire is less intense. . .

Turf charcoal.

“The secret of the success and of the profitable working of the moors and ogs in Holland, and of the generally flourishing condition of her turf indusry lies nearly altogether in cheap means of transit. All the principal turf-roducing centres are intersected by canals capable of being navigated by the rge turf-carrying lighters, from 80 to 200 tons dead weight capacity, and s the bog is opened out for turf cutting the canals are simultaneously pushed orward, so that the expense of transit at the place of production is reduced o a minimum. As regards the home consumption of turf, it is also so egulated as to do away with every manipulation of the article which can ossibly be avoided. . . The expense of carriage to the port of shipment, ven under the above favorable circumstances is 25 to 50 per cent. on the cost f production, and it is very clear that the article is one which cannot possibly ear any extra expense of manipulation or transport. The climate of this counry, though more humid than that of most parts of the continent of Europe, s still sufficiently dry, especially in the early part of the year when lengthned periods of dry easterly winds prevail, to encourage the production of urf, while the consumption as a household fuel prevails so very generally ver the whole of Holland that in spite of the competition of coal and coke continues to hold its own in this respect. Besides this household conumption, the brick-making industry is the chief consumer of turf, which is ansported by lighters direct from the bogs to the brick-making estabshments, situated in great numbers along the principal rivers of Holland, here brick clay of an excellent quality is found. The consumption for is purpose is a very large one, the turf forming a clean, practical and conomical fuel for brick-burners, whose ovens are specially arranged for s use.”

Profitableness of production depends on cheap means of transit.

RUSSIA.

According to Mr. Consul Michell at St. Petersburg, peat fit for fuel is found Russia in forty-five of its provinces on an area which it is calculated tends over 100,000 square versts (67,000 square miles), and is capable of ielding 875 milliards of poods (14 milliards of tons). No exact informaon as to the quantity of peat cut in Russia is in existence. It can only nerally be said that it is found in the provinces of Moscow, Vladimir, jni-Novgorod, Orel, Kharkoff, Kieff, Esthonia and St. Petersburg, where is prepared as fuel for manufactories, sugar works and other industrial tablishments, as also for locomotives. Among the peat bogs which belong the crown those lying in the provinces of St Petersburg, Moscow, Orel, iazan, Vladimir, Tamboff and along the Kursk-Kieff line have been sureyed. The result of the survey proves that the peat bogs of the crown in e above localities contain no less than 100 millions of cubic feet of peat excellent quality. Some of these peat bogs are leased under the crown by rivate individuals, notably in the district of Pokrovsk, of the province of ladimir, the lessees of which are Savva, Morozoff & Co., owners of the tensive Nikolsky cotton manufactory. Peat bogs belonging to private dividuals are worked near the station of Orekkhova of the Nijni-Novgorod ilway and in the neighborhood of Moscow, viz, at Krilobsky, nine miles est of that city; at the village of Nikolsky, along the high road leading to

Extensive areas of peat in Russia.

St Petersburgh; near Gorenky station, on the Vladimir road, where it is worked for the Reutovsky cotton mill of the Morozoffs; near the station of Libertsi of the Riazan railway, in several parts of the provinces of Orel, and in the neighborhood of St. Petersburg.

Manufacture of compressed peat.

The peat used in Russia appears to be for the most part of the ordinary hand-cut, air-dried variety, but an account is given of establishments at Perst and at New Woidoma in which machinery of German manufacture is employed for the production of peat in a compressed form. These appear to be in successful and profitable operation, and it is stated that the working expenses of the establishment at Perst were almost completely covered in the first year.

SWEDEN AND NORWAY.

Production and uses of moss litter.

Manufactories for the preparation of moss litter have been established in various parts of Sweden and Norway, and the value of peat mould (torfmull) as an antiseptic and for covering fæcal matter, which in Swedish towns is carted away solid, is being largely recognized. Mattresses and other articles of bedding are also manufactured from the peat fibre, as well as loose inside soles for boots and shoes. For surgical purposes and compresses the moss is chemically prepared with disinfectants.

Mr. Consul Duff of Gothenburg states that in his district peat is not yet used for industrial purposes on any extensive scale; some glass-works however having large tracts of peat in their immediate neighborhood have found it to their advantage to work the peat, and usually employ machinery of German construction for raising and shaping the material into a form of less bulk. Mixed with small coal it makes an excellent fuel. Also some iron-works use peat, but not largely; it is of course unmixed, and only used for certain purposes owing to its purity.

Mr. Duff also gives the following particulars respecting the manufacture and export of moss litter within his district:

Raising,

"By means of sharp spades the peat is cut into lumps about the size of a large brick, which are spread on the peat bog to dry. After some time these are gathered into small piles and placed so as to admit the access of the wind to take away all moisture.

housing,

"When the process of drying, which takes from a few months to a year, is completed the peat is collected and conveyed on portable rails to the barn, or placed in large stacks or piles to protect it as far as possible from rain.

manufacturing and

"The peat is now ready for the machinery, which in most cases is worked by steam. The lumps or bricks are brought in contact with a rotating wheel fitted with sharp steel pegs and are instantly torn to pieces, whereupon it is carried by an elevator to a large revolving screen where the separation of the two qualities of moss litter, namely, 'torfmull' and 'torfstro' takes place; the former being a soft substance similar to cigarette tobacco is used for closets, and the latter which is of the consistency of oakum is mostly used in stables and cowhouses.

baling the litter.

"Powerful presses compress the litter into bales, which are held together by means of wire and wooden ribs. The size of the bale is 100 x 75 x 50 centimetres, and the weight about 100 to 120 kilog. The price is 20s. per ton free on board at Gothenburg.

Export trade.

"Although there are numerous enquiries for Swedish moss litter, particularly from Great Britain, still the export is very insignificant, owing principally to the high freights and the difficulty in reducing the weight of the litter.

"The average weight of the Swedish litter is 15 to 20 kilog. per hectolitre, whereas that of the Dutch litter, which in every respect is far superior to the Swedish, and of which a considerable import to Sweden takes place, is only 10 kilog. per hectolitre."

information on the present position of peat products in
y Herr Th. Palmberg of Stockholm, his letter being dated

gs of Sweden cover an immense surface, amounting to many
nor are they confined to any one part of the kingdom,
of them are either in the extreme northern provinces or in
Dalecarlia, Vermland, Smaland, Halland and North Scania.
nd and in Lapland there are peat bogs hundreds of square
consisting of turf of excellent quality; in other provinces
f of different qualities, and occasionally different qualities
th in one and the same bog. The depth of the turf varies
and even more. It is an old custom in the southern pro-
rf as fuel in private dwellings; especially is this the case in
e coast where there is no wood to spare for burning. To a
xtent bogs were also formerly used for raising crops. But
or forty years increasing attention has been paid to the
rom Sweden's plentiful supply of peat bogs, both as regards
nd as regards the fuel to be obtained from them for use in
nanufactories. During the last ten years increasing interest
bed in the supply of peat litter.

Great area of peat bogs in Sweden.

A growing industry.

possibilities of their cultivation it may be mentioned that
of bog have been brought into cultivation in the southern
ces during recent years. In these same provinces turf for
t out in enormous quantities every year by most of the iron-
ndustrial establishments situated inland and possessing bogs

merous ways of treating the turf (when cut) by machinery.
machines for disintegrating, rolling and pressing it, and
er drying. The actual drying generally takes place on a
of bog itself, either by spreading it out or putting it up
es the above air-drying of the turf, several iron-works have
lished ovens of various sorts for the further dessication of
ovens have in general given very good results. They are
lus heat of the furnaces, which thus costs nothing, and yet
n 25 to 30 per cent. in value from the process.

Processes of the manufacture of peat.

Curing with surplus heat of iron furnaces.

turf for burning in dwelling houses in the southern pro-
d is scarce is chiefly cut brick-shape by spades made for the
dried at the place where it is cut by simply spreading it
. It costs very little to cut, but is rather loose owing to
in so primitive a fashion. Such turf as is intended for
is always worked up or disintegrated in one way or another,
d solid when dried and thus give more heat when burnt.
f is used in the furnaces either by itself or else mixed with
At wood-pulp factories it is used for drying the pulp. Turf
glass-works, brick-works, as fuel for steam engines, etc.
th of Sweden, and even there in but few cases, that there
e preparation of turf for sale as fuel.

Peat fuel for dwelling houses and for industrial purposes.

ible to give any exact figures as to the amount of prepared
ed in Sweden for burning, as no figures are recorded. Its
year by year owing to its being a cheaper fuel than coal.
0,000 tons a year may be said to be employed in metallur-
rent kinds.

Increasing us of the fuel.

roducing well made turf for fuel may be given as from 4s.
on, according to the price of labor in different places. Good
ected to contain from 30 to 40 per cent. of heating material,
o 10 per cent. of ash, and there is an enormous quantity of
n.

Cost of production.

Peat litter factories.

"Of late years quite large quantities of peat litter has been prepared in southern and central Sweden, partly by twenty large peat-litter factories which produce it for sale, and partly by private owners of peat bogs who take it for their own use. It is of the very best quality, far excelling that produced in other countries. This peat litter is made from pure sphagnum, or immature moss unmixed with other sorts of moss. Each peat-litter factory makes about 15,000 to 30,000 bales (200 lb. each), and it is sold here in Sweden for about 1s. 8d. per bale. A much finer quality (called torfmull) sells for from 1s. 11d. to 2s. 2d. per bale."

XVI.

THE MINING LAWS OF ONTARIO.[1]

Ontario.

The first Mining Act.

Early control exercised by Orders in Council and reservations in the patent.

For three-quarters of a century Ontario was known as Upper Canada. For two thirds of that period it had a Legislature and Executive of its own, and for the rest of the time it was united with Lower Canada, now Quebec. The union of the two Provinces ended with June, 1867, and on the first day of July Upper Canada became a member of the new Confederation with the name which it now bears. Three years before this date the first statute regarding Mines and Mining was enacted by the Legislature of the United Provinces, having for its title "The Gold Mining Act." This and the Amendment Act of 1865 were the only statutes which dealt with Mines and Mining down to the date of Confederation; all other control was exercised under the authority of Orders in Council and by reservations in the patent from the Crown. Under the latter provision gold, silver, copper, tin, lead, iron and coal were so reserved down to the end of 1823, and gold and silver until the 13th of July, 1866, when a regulation was approved by the Governor General in Council directing that in all letters patent for lands the clause reserving mines of gold and silver be omitted.

EVOLUTION OF THE LAW.

From particulars to general principles.

Successive Regulations, 1845-53

Priority of claims.

Area and price of mining locations.

The necessity for exercise of Government control over mineral lands and mines arose in 1845, the first year of exploration and discovery on the north shore of lake Superior. At first each case requiring executive action was dealt with by Order in Council as it came up, but in the course of time certain principles were evolved to which general application was given under the form of regulations. These however were changed six successive times within the space of one year and after a seventh modification in January of 1847 they stood unaltered for nearly seven years. For license to occupy a location and open mines thereon priority of discovery by exploration was a first requirement; but no license could issue until the explorer reported the result of his discoveries to the Government. It was also necessary that a scientific agent of the Government should have an opportunity to mark the boundaries of limits, determine the direction of boundary lines in the case of different courses of veins on adjoining locations, and examine the statements of exploration furnished by an applicant. Reports pointing out and selecting a location were classed according to receipt and held to be the best evidence of discovery; possession by the building and occupying of a hut was proof of the next value; while priority by application was assigned a third rank of value. The extent of a mining tract was first fixed at one mile in front by five miles in depth; but afterwards in response to the petitions of explorers the limit was extended to two miles in front by five in depth, the length to be with the course of the mineral vein. The land was sold in fee simple at eighty cents (4s.) per acre, $600 payable at the time of purchase or when the certificate of location was issued, to cover the cost of surveying and other contingent expenses, and the balance in five yearly payments with interest. Upon these terms the lands on lakes Huron and Superior were declared open for sale at the minimum price of four shillings per acre in blocks of ten square miles; and although it was provided that all grants should be subject to such regulations to ensure the working of the mines as Parliament might thereafter enact, it does not appear that any conditions were required or imposed by that body.[2]

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[1] A paper read at the meeting of the International Mining Convention at Montreal, February 24, 1893. A. B.

After a trial of seven years the Government became convinced that these regulations were too burdensome upon the miners. The system of allotting mining tracts had not realized the anticipations formed of it; neither had it enabled individuals desirous of engaging in mining pursuits to effect their objects without compelling them to purchase locations of so extensive an area as to call for a needlessly large outlay on acquiring a right to explore and mine where the signs were favorable. Accordingly in September, 1853, a new set of regulations was introduced by Order in Council, applicable to Upper Canada only, under which the Commissioner of Crown Lands was empowered to issue to any person upon payment of $100 (£25) a license to explore unceded lands in any county or section of the Province (named or described in the license) for copper, lead, iron, tin, marble, gypsum, earths or minerals. The license was to remain in force for two years and the holder of it might take possession of a tract not exceeding 400 acres of unoccupied land, 40 chains front by 100 in depth, and "report his discovery and selection accurately by letter and map within six months from the issue of the license, accompanied by an affidavit made by himself and some other credible person proving that no counter occupation or workings exist." At the expiration of the term of two years the license holder was required to complete a purchase of the tract selected by him at the rate of $1.50 (7s. 6d.) per acre in one sum or forfeit his right. It will be observed that these regulations did not apply to gold and silver unless they could be included under the general designation of minerals.

Regulations of 1853.

In the next regulations adopted by Order in Council in March, 1861, gold and silver were specifically excluded, as doubtless it had been intended all along that they should come under the regulations of 1845-7. The new regulations also abolished the fee of $100 for permission to explore, and provided that locations be sold to the first applicant agreeing to the following conditions, viz: "That for mining purposes tracts comprising not more than 400 acres each be granted to parties applying for the same at the rate of $1 per acre to be paid in full on the sale," the applicant furnishing a plan and description of the locality to the Department of Crown Lands, "and on condition that such mineral location be worked within one year from the date of the said grant." It was further provided that a patent should not issue until two years from the date of the purchase, and then only upon proof that the purchaser or his assignee had continued to work the location *bona fide* for at least one year previously.

Regulations of 1861.

In April of the following year working conditions were abandoned as to future sales, and it was agreed that patents should issue on the payment of the purchase money, but subject to a royalty of 2½ per cent. on ores raised or mined, payable on their value as prepared for market at the mine.

Regulations of 1862.

Royalty,

In March of 1864 the royalty of 2½ per cent. was changed to a tax or duty of $1 per ton on all ores except gold and silver, payable on removal from the mine, and this condition was made to apply to all mining lands sold under the regulations of 1862. It was also provided by the amended regulations of 1864 that not more than one tract of 400 acres should be sold to one person.

changed to a specific tax on all ores except gold and silver in 1864;

The new tax or duty remained in force only one year, a regulation of April, 1865, directing that the clause requiring such payment should no longer be inserted in the grant or patent. The same regulation also authorized the Commissioner of Crown Lands at his discretion to omit the clause reserving mines of gold and silver in patents for lands on the shores of lake Huron and lake Superior.

but royalty and reservation practically abandoned in 1865.

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[2] The Mining Location ticket issued under the Rules and Regulations of the Orders in Council of 7th October and 2nd November, 1846, contained the condition that if the locatee should neglect to commence and *bona fide* carry on mining operations upon his location within the period of eighteen months from the date thereof he should be held to have forfeited the location and license.

Regulations of 1866.

The last of the regulations for the sale of mineral lands by Order in Council were brought into operation in July, 1866, and dealt chiefly with ores of the base metals. They provided for the sale of mining tracts in unsurveyed territory in blocks of 200 or 400 acres; the survey of tracts at the cost of the applicant by a Provincial Land Surveyor; the furnishing of plans, field notes and descriptions showing the connection of a tract with some known point in previous surveys, so that it might be laid down in the office maps of the territory; and payment at the price of $1 per acre at the time of making application. These regulations also provided that lands in unsurveyed territory should be sold by the Department and in surveyed townships by the local agents, and that in all letters patent for lands the clause reserving gold and silver should be omitted.

The Gold Mining Act of 1864.

In 1864 there was a rush of miners and prospectors to regions of Lower Canada in which alluvial gold had been discovered, chiefly on the St. Francis and Chaudiere rivers and their head waters; and in that year, as already mentioned, the Legislature passed the first Act on the subject of Mines and Mining known as "The Gold Mining Act." It was a statute of 40 sections, drawn up with much nicety and particularity for the mining of alluvial and quartz gold and the protection of miners' rights, for appointment of inspectors of divisions with large powers, for staking out claims of small areas, for licenses to mine, for licenses to mill, for sworn returns of gold taken out, for preservation of the peace, and in short all the trappings which the wit of legislators might devise for conserving the interests of the Crown and protecting the rights and fixing the obligations of miners in a placer diggings gold land.

Exclusive powers to make laws for management and sale of public land assigned to the Provinces by the B. N. A. Act.

Gold mining in Hastings.

The rush of miners and prospectors to the Chaudiere valley was of short duration. Yet the Act of 1864 not only remained with trifling amendments the law of the country down to the end of the union of Upper and Lower Canada; it continued to be the law after Confederation, when the exclusive powers to make laws for management and sale of public land belonging to each Province was assigned to the Provincial Legislatures by the new constitution, he British North America Act. A good reason for its continuance in Ontario was found in the discovery and working of veins of gold quartz n the county of Hastings, which had been set apart as a mining division under the Gold Mining Act on the 17th of November, 1866, ten days after he Commissioner of Crown Lands had received information of the discovery f gold in Madoc.[3]

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[3] Under date of November 6th, 1866, Hon. Billa Flint of Belleville wrote the following etter to the Commissioner:

MY DEAR SIR,—There is a great stir here at present about Gold in Madoc.

Already one lot has been sold to Americans for about $30,000, and the gold is very rich; t also begins to be developed in other places in Madoc than on lot 18, 5 con.

My object in writing is to say to you that I believe it exists in Elzevir, Hungerford and ther townships both east and west of Madoc, and my desire is to put you on your guard as o sales of land, as the people are going mad about lands for mining purposes.

I have for years been satisfied that there was a vein of gold running somewhere about ast and west across the Back Country, and have had several specimens from Quartz Rock or the past five years.

I know Geologists will not admit that we have mineral wealth, but I do know that they annot tell where mineral is until we find it for them; and I have no faith in their statenents, for when I have given Sir Wm. Logan specimens he won't return them, nor tell me hat they are.

The present excitement if kept up for a short time will bring our rocky land to high gures. Lands near this Gold discovery that could have been got for 4$ an acre 10$ is efused for them now; this shows the sanguine feeling of both holders and purchasers.

So if there is any good chance, of which I have no doubt, let the Government enjoy for he good of the whole country the benefit by sale or leases. Yours, etc., etc., BILLA FLINT.

HON. A. CAMPBELL, Commissioner of Crown Lands, Ottawa.

On this letter the Commissioner made a memorandum as follows:

I have no faith in the gold being found in paying quantities; the Chaudiere country romised much greater riches, but the only persons who have made any money there have een speculators on the delusion of others in the price of lands, and the few who have found old in alluvial deposit. If there be any Gold in the Townships named by Mr. Flint it is in tu and the expense of working it will be found to reduce the affair to the laws of ordinary dustrial pursuits. The lands however in the Townships named should be treated as Gold nds are in Chaudiere - sold at a price of $2 per acre cash, subject to Gold Mining Act.—A.C.

Gold and Silver Mining Act of 1868.

In the first session of the Legislature of Ontario after Confederation the Act of 1864 was repealed, and one known as "The Gold and Silver Mining Act of 1868" was enacted in its stead—provision for silver mining having been deemed necessary as a result of discoveries on the north shore of lake Superior in the previous year. The new features of this Act related chiefly to the granting of licenses to explore and mine for gold and silver within the limits of a mining division, and to the levying of royalties. Under the former Act a miner's license was of two kinds, viz., (1) a Crown Lands license, which upon payment of a fee of $2 per month authorized the holder to mine on any unsold public lands, and (2) a Private Lands license, which upon payment of a fee of $1 per month and after agreement with the proprietor authorized the holder to mine on any private lands within the limits of the division. Under the latter Act the fee for a license was reduced to $5 per year, and it authorized the holder to explore and mine for gold and silver upon any public lands in a division, but subject to the levy of a royalty of not less than two nor more than ten per cent. on the gross amount of gold or silver mined—the rate to be fixed by the Lieutenant-Governor in Council and variable for different mining divisions and different mines according to the yield. Proprietors of private lands were accorded the right to mine for gold and silver upon their own lands, subject to the royalty, and private licenses were abolished.

Miner's license.

THE GENERAL MINING ACT OF 1869.

The first Act to deal with all ores and minerals by legislation.

In the following year this Act was repealed, and there was passed in place of it "The General Mining Act of 1869," a measure which for the first time dealt by legislation with ores and minerals of all classes. It however retained most of the provisions of the former Act, applying them to the occupying and working of "mining claims" under miners' licenses when situate within any mining division, but abolishing the provisions relating to alluvial mines. Larger areas were designated as "mining locations," consisting of 80, 160, or 320 acres, the price was fixed at $1 per acre, and if the locations were in unsurveyed territory it was necessary to make a survey and file plans and descriptions as required by the regulations of 1866. To a large extent indeed the old regulations became in this measure crystallized into statutory law. By this Act also all royalties, taxes and duties reserved by any patent theretofore issued in respect of any ores or minerals were declared to be repealed and abandoned; all reservations of gold and silver mines contained in any previously issued patent were rescinded and made void;[4] and it was provided that no reservation or exception of mines or minerals should thereafter be inserted in any patent from the Crown granting any lands sold as mining lands.

The old regulations crystallised into statutory law.

Royalties abandoned and reservations made void.

These general references to the Act of 1869 will suffice to exhibit the course of the development of mining legislation in our Province; but I pass by the details and take up the law now in operation.

THE MINES ACT 1892.

Divisions of the Act.

In "The Mines Act, 1892," the Act of 1869 and all subsequent Acts dealing with mining lands, mines and mining have been consolidated and amended. It consists of four parts, viz.: General Provisions, Mining Locations, Mining Claims and Mining Regulations, and for convenience it may best be considered under these several heads.

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[4] It has been stated that most of the patents issued down to the end of 1823 reserved for the Crown mines of copper, tin, lead, iron and coal, as well as of gold and silver; but inasmuch as only the two last named were by the Act of 1869 deemed to have passed with the lands to the owners in fee simple, it may be assumed that the right to the others in all cases where the reservation was made in the patent is still in the Crown.

Bureau of Mines.

The administration of the mineral lands is presided over by the Commis- ner of Crown Lands, and connected with his Department is a Bureau of ines, established to aid in promoting the mining interests of the Province. e Director of this Bureau acts under the instruction of the Commissioner, d is clothed with all the powers, rights and authority which an inspector local agent may exercise in a mining division or locality, and such other wers as may be assigned to him by regulation for carrying out the provi- ns of the Act. In practice the Bureau has charge of the mineral lands in rveyed territory (unsurveyed territory is in charge of the Department), d through it all correspondence and business relating to the selling, leasing d working of such lands is carried on. It also publishes an annual report furnish information on the mineral resources of the Province, the progress mining and metallurgical operations, the conditions of mines as regards e health and safety of miners, and the observance of regulations for the ployment ef labor.

Royalties on ores and minerals.

As in the original Act, any person may explore for mines or minerals on y unoccupied Crown lands, and such lands if supposed to contain ores or inerals may be taken as mining locations, or if in a mining division as min- g claims. But lands so taken do not now carry the ores or minerals solutely with the fee simple, as any acquired subsequently to the 4th day y of May, 1891, are subject to a royalty for the use of the Province. It is interest which the Crown reserves in mineral lands, and may be regarded part of the price put upon them by the Act at the time of sale or lease. ccordingly no higher rate of royalty may be levied than is provided by the atute in force when the lands are granted. The royalties are in no case to imposed or collected until after seven years from the date of the patent or se (but extended in the case of original discovery to fifteen years), and en they are to be calculated upon the value of the ores or minerals at the t's mouth less the actual cost of labor and explosives employed in raising em to the surface. In this way and under these conditions silver, nickel, d nickel and copper ores are subject to a royalty of three per cent., iron ore two per cent., and all other ores to such royalty as may be imposed by der in Council not exceeding three per cent.[5]

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[5] The question of royalties upon minerals has been warmly debated in Ontario during e past two years, and the Legislature has been charged with adopting in this matter a ressive and reactionary policy towards the mining industry. Yet it has never been shown w royalties paid to the State differ from those paid to a private owner; and throughout rope and America the private owner of mineral land is often found leasing his property to niner or company of miners, and levying rents and royalties like any lord paramount of a gdom. In some countries this is the prevailing practice; but occasionally the charges are nd to be so heavy and the conditions so exacting that the miners prefer to buy the property tright at any price that can be agreed upon. Thus a few years ago the Reading Railway mpany paid $50,000,000 for 100,000 acres of coal lands in Pennsylvania, which has proved be a ruinous bargain; and doubtless the lessees of Dolcoath mine in Cornwall would also ve preferred, if they might, to pay an enormous sum for the fee rather than submit to the ner's fine of £25,000 at the last renewal, although he had up to that time been paid £260,000 royalties and had not contributed a dollar to the development of the property.

In the case of the private owner there is no uniformity in the rate of royalty, which pends in part on the known or supposed value of each separate location, and in part upon success of the owner in making a good bargain, the aim always being to get the highest te and best terms possible. Furthermore, in addition to royalty a fixed rental is sometimes ovided for, with a premium or fine at the time of renewal. In the case of an iron ore operty in Scotland some years ago the fixed rent was £12,000 a year, and 7s. 6d. per ton yalty. In Michigan, Wisconsin, Minnesota, New York, New Jersey and Pennsylvania, ners of mineral lands are paid large sums every year as royalties, although often their only estment has been the payment of the original purchase price to the State.

On the Mesabi iron range in Minnesota twelve mining locations were leased last year at yalties ranging from 30 to 65 cents per ton, the average being 53 cents. Under the terms the contracts the lessees are bound to pay royalties on a minimum output of 1,550,000 tons ch year, the aggregate of which will be $820,000. Eleven of those properties were purchased m the United States Government at $1.25 per acre, and the owners will derive from them yearly income of at least $560,000 in royalties. One property of 160 acres is land sed from the State under a royalty of 25 cents per ton, and it is sub-let subject to a nimum yearly output of 400,000 tons and a royalty of 65 cents per ton. On this output erefore the State will receive $100,000 a year, while the private lessee will receive $160,000.

Mining locations, their area and price.

Mining locations are required to be of definite form and size, whether they are situated in unsurveyed territory or in townships surveyed into sections or lots. In the territory beyond lakes Superior, Huron and Nipissing and the French and Mattawa rivers, wherein for the most part the great mineral-bearing formations of the Province lie, each location in a surveyed township must consist of a half, a quarter, an eighth or a sixteenth of a section; and if in unsurveyed territory it must be of rectangular shape with outlines of astronomical bearings, containing 320, 160, 80 or 40 acres, surveyed at the cost of the applicants and connected with some known point in previous surveys or with some other known point or boundary. The price of such locations ranges from $2 50 to $3 50 per acre, dependent on its distance from a railway and whether it is in surveyed or unsurveyed territory. For locations south of lake Nipissing the price ranges from $2 to $2.50 per acre. Any greater sum however may be charged where a district or locality rich in mines or minerals has been set apart by regulation under Order in Council, or the land in such a locality may be temporarily withdrawn from sale.

Tenure of locations by grant in fee simple, or by leasehold for a term of years.

The applicant for locations has the choice of obtaining a grant in fee simple at the prices named above, or he may obtain a lease at $1 per acre for the first year and 25 cents per acre for each subsequent year if the lands are in the territory north of the lakes; if south of the lakes the first year's rental

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Discoveries of ore on lands owned and leased by the State promise already an annual income of a quarter of a million, to be paid directly into the State Treasury in the shape of royalties, and according to H. V. Winchell of the State Geological Survey the revenue of the State from this source will within three years reach a million dollars. Upon the twelve sub-leases of locations on the Mesabi range already made the holders from the State and Federal Governments have been paid $270,000 of royalties in advance of any working, and nearly all the iron mines in this State are paying royalties to the private owners. By the Act of 1889 the State leases its iron bearing lands under a fifty years contract at a royalty of 25 cents per ton (the minimum being fixed at $1,250 a year whether ore is raised and removed or not), but its provisions do not of course apply to lands purchased from the Federal Government.

In Pennsylvania the ores and minerals in public lands have gone to the purchaser of the surface rights, including extensive land areas of hard and soft coals. Mining companies have purchased blocks of these lands from the private owners at prices ranging from $200 to $500 per acre, but usually the lands have been let by the holders to miners at royalties ranging from 25 to 50 cents per ton. How such parties have benefited by the bounty of nature is well illustrated by the case of the Girard Estate lands in Schuylkill county. When hard coal was first discovered in this county about a hundred years ago the land was quickly taken up at the low price at which public lands in the State were then held, but for more than thirty years no mining operations were undertaken upon it. About 1828 a block consisting of 18,233 acres was bought by Stephen Girard under foreclosure sale by the State "at practically nominal prices." The management of this land passed into the hands of the Philadelphia Board of Directors of City Trusts in 1832, as provided by Mr. Girard's will, but no coal was raised upon it until 1863, when lots began to be leased to mining companies at a specified royalty, increasing one cent per ton a year for fifteen years—the term of the lease In the first year the revenue from the mining lots was $4,246. In the last year, 1892, it was $623,694, whereof $618,096 was from royalties (nearly 42 cents per ton), and the balance from rents—"a sum," the directors say in their report, "which will be largely increased for many years, and from which there will be no material decrease for twenty-five years at least." Three-fourths of the net receipts from royalties is credited to capital account and permanently invested, but "these receipts increase so rapidly that it is difficult to find legal investments for them." The sum now invested by the board, a portion of which however has come from other sources of the estate, is $3,378,925, and last year it yielded an income of $139,839. Had the State reserved the minerals the revenue on the quantity of hard coal sent to market last year, calculated on the royalty paid upon coal taken from the Girard Estate land, would have been $17,385,000; and had half the rate been paid upon soft coal in addition, the aggregate for royalties paid in the year would have been $25,000,000. In so far as the price of coal is affected, it could make no difference whether this money was paid to private individuals or the State Treasury; but as a matter of public interest the difference is obvious. The advocates of private ownership will say, as some of them have said, that reservation of minerals by the State hinders development, and that private ownership tends to promote it. This has not been the case in Pennsylvania, where most of the best coal lands were held in idleness by the private owners for more than a generation.

"Minerals in the United Kingdom," the Final Report of the Royal Commission on Mining Royalties says, "are usually worked by lessees and not by the proprietors." This Commission was appointed in August, 1889, the evidence and information which it collected, including the final report, has been published in five volumes or blue books, and its work was not concluded until March 24th, 1893. These two paragraphs, in which the leading conclusions and recommendations are summarized, are all that need be quoted here: "I. We estimate that the amount paid as royalties on coal, iron-stone, iron ore and other metals worked in the United Kingdom in the year 1889 was £4,665,043; and that the charge for

i0 cents. per acre and 15 cents thereafter. Leases are issued for a term
ten years with a right of renewal for a further like term at the same rental
:he conditions have been observed, and thereafter they may be renewed
m time to time every twenty years at such rent as the regulations provide.
t the lessee may at any time become the purchaser of the lands held by him,
which case the sum paid for the first year's rental is treated as part
the purchase money. This leasing system appears to be growing steadily
favor with mining men, and a large proportion of the lands now granted
mining purposes are granted under its provisions.

Locations granted subject to working conditions.

Whether a location is held in fee simple or by lease it is subject to certain
rking conditions, being an expenditure during the first seven years after
issue of the patent or lease in actual mining operations of $4 per acre
ere the area of the location exceeds $160 acres and of $5 per acre where it
of less area; and such expenditure may consist of labor performed by grown
n at the rate of $2.50 per day, or for explosives or other material for min-
used on the location. In default of so much work by a *leaseholder* the
se becomes void and the location reverts to the Crown; in a case of default
an *owner* all mines, minerals and mining rights so revert, but the owner
ains all interests in the location as agricultural land.

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yleaves for the same year was about £216,000. II. We are of opinion that the system of
alties has not interfered with the general development of the mineral resources of the
ited Kingdom, or with the export trade in coal with foreign countries."
Coming back now to Ontario, one or two instances of the working of private royalties
y be cited. The lands of the Canada Company are either leased for a term of seven years
old in fee simple. In the former case the lessee covenants not without leave in writing to
n any mine, or dig or bore for oil or natural gas, or allow any work connected therewith
e carried on upon the premises. In the latter case the land is conveyed subject "to the
ervation of all or any of the mines, minerals, mineral oils and natural gas on, in, or under
said lands," and to such powers, privileges and covenants to the company for searching
working, getting and disposing of the same as the company may deem proper. In one
reported last year this company let a phosphate location in the county of Frontenac at a
alty of $2 per ton. The other instance is drawn from the discussion which took place at
meeting of the International Mining Convention upon the reading of this paper. Mr.
Cameron, manager of the Dominion Mineral Company's work at Sudbury (who expressed
ecided opinion favorable to the Ontario mining law), said he had been in charge of the
pany's business only a few weeks when numerous offers were made to him of unimproved
ls held by private owners in small lots at prices ranging from $40.000 to $100,000 and
alties in addition ranging from 25 to 50 cents per ton upon nickel ores. And the parties
n whom those offers came, Mr. Cameron said, were the ones who made the strongest objec-
s to The Mines Act. In the sale or other disposal of mining lands the interests of the
ntry ought to have the chief consideration, and in his opinion these had been conserved by
Act, while at the same time the miners were treated with fairness and liberality.
Now as to the conclusion of the matter. In almost every country, but especially in Great
tain and the United States, the practice largely prevails amongst owners of mining lands
evy royalties on the minerals raised from them. There is no uniformity in the rate of
royalties, or of the rent charges for occupying the lands, or of the time for which the
e is to run. Everything depends on the opportunities for driving a good bargain; and
ost invariably every ton of ore mined must pay royalty to the owner of the land whether
re is profit in it for the miner or not, and a certain amount of royalty must be paid every
r whether the ore is mined or not. Under the Ontario Act, if the land is sold in fee simple
the owner's, to make the best use he can of it, but subject to the royalty provided by the
at the time of sale; if it is leased, the lease is for a fixed term and renewable. The
alty is fixed also and cannot be increased, although it may be reduced; and if the miner
s not make any profit on the ore he wins—if its value at the pit's mouth is no more than
cost of labor and explosives in raising it—the Government can exact no royalty from it.
hen the system of private royalties is free from objection, if as in Great Britain a tribute
23,000,000 a year may be imposed on the industry by the private owners of mineral lands
not interfere with the general development of the mineral resources of the country, how
it be affirmed that a very much lower and fairer rate of royalty can repress or interfere
h it in Ontario where, when royalties begin to be levied at all, they will be paid into the
asury of the Province instead of to the private owners of lands that once were the lands
he whole people? Or is a State the only landowner which cannot take the measures com-
nly adopted by individuals and companies to derive a revenue from royalties without being
used of adopting a repressive and reactionary policy by the parties who themselves are
king to make incomes and fortunes out of royalties? If a share in the bounty of nature,
h as unquestionably ores and minerals are, may justly be reserved to the people, the time
provide for it is while the lands are part of the public domain, not after they have been
or otherwise alienated to private persons and corporations who have no interests to serve
their own.

Reservation of minerals on free grant lands and lands sold for agricultural purposes.

Under the system of free grants to settlers adopted in 1868 all minerals have been reserved to the Crown, and by an amendment to the Public Lands Act in 1891 they are so reserved on all lands now sold for agricultural purposes. So it has come to pass respecting those lands that two classes of rights are recognized, viz., surface rights and mineral rights. The owner of the surface rights may apply for a patent or lease of the mining rights on his lot, and his claim possesses priority except where there has been an earlier application and a deposit of at least half the purchase price or rental made, or in case of original and bona fide discovery of valuable mineral by a subsequent applicant within one month prior to the application of the owner of surface rights. In either case the price per acre of a patent or lease is one half of the rates for a mining location where surface and mining rights are not separated. But a prospector is limited in his right to go upon private land on which the minerals have been reserved to explore it. He cannot enter any portion of a lot used as a garden, orchard, vineyard, nursery, plantation or pleasure ground, or upon which are crops which may be damaged by exploring, or on which is any house, church or cemetery, except with the written consent of the owner or locatee. Neither can the person to whom mining rights have been conveyed go on the land to open it for ores or minerals until he has first agreed with the owner of surface rights for compensation and damage; but should the parties fail to agree it is in the power of the Director of the Bureau of Mines to order and prescribe the manner in which compensation shall be ascertained and paid or secured, either by an arbitrator appointed by himself or by a suit or action in any county or district court between the parties.

Surface rights and mining rights.

Pine trees reserved to the Crown, but owner or lessee of a location may cut and use for certain purposes.

It is to be observed that in all sales or leases of mining locations all pine trees thereon are reserved to the Crown, and should the locations lie within a timber limit the holder of a license to cut timber on the lands may enter upon them and cut and remove the trees. Yet although the patent or lease expressly reserves pine timber, the owner or lessee may cut and use all pine and other trees needed for building, fencing and fuel on the land, and for any purpose essential to working the mines upon it, as well as cut and dispose of all trees required to be removed in clearing the land for cultivation. But a lessee is restrained from using pine trees for fuel other than dry pine, and should he intend to clear any portion of the land for cultivation he is required to give the holder of the timber license three months' notice so that he may remove any pine on the area to be cleared. If at the end of that period it is not removed the lessee may cut and dispose of all trees on the land to be cleared, but subject to payment of the same dues as are payable by the holder of the license. The privileges of the lessee are also circumscribed in another particular. Should he during the first ten years seek to cut timber other than pine upon his location beyond what is needed for building, fencing or fuel, or in the course of actual clearing for cultivation, or for any purpose essential to the working of the mines, he must first apply for leave to the Commissioner of Crown Lands, who may grant authority to cut the timber and fix the rate of dues to be paid upon it. But inasmuch as a lessee may forfeit and abandon his title to a location by the simple process of neglecting or refusing to prepay the yearly rent, it is not reasonable that he should be treated with the same liberality as an owner in respect to the timber upon the land. The important point is however that both owner and lessee of a mining location are entitled to the free use of all the timber upon it which may be wanted for mining purposes, while the owner is entitled to the free use of all timber excepting pine upon it for any purpose. The owner or lessee of mining or underground rights has of course no claim to use of the timber upon a location which, as far as it goes at all, goes with the surface rights.

Exemption in case of lessee.

The important point.

Mining claims.

The portion of the Act which relates to mining claims and the manner of acquiring, holding and working them is for the present inoperative, inasmuch as no tract of country has been declared or set apart as a mining division.

he reason no doubt is that circumstances have not arisen to call for utilizing he system for which it provides, either by reason of the distance of mining elds from surveyed or settled territory or the discovery of fields very rich in old or other valuable ores where small areas would satisfy the desires of ining men. Mining locations are preferred, and there is not a demand for ining claims. Yet it is possible that the demand may arise in some por- on of the vast mineral-bearing formations of the Province, and in view of at contingency it is well to have a provision ready at hand to which effect ay be given at the will of the Executive.

Areas of mining claims.

In the Mining Act of 1864 the area of a claim which might be staked ut by one person holding a license was less than half an acre and by a com- any of persons not more than about $2\frac{2}{7}$ acres, and these areas were doubled y the Act of 1869. The Mines Act, 1892 provides for staking out by one erson a claim 660 feet along a vein by 330 feet on each side of it (about 10 cres), and by a company of persons a claim not exceeding at the maximum 320 feet along the vein by 330 feet on each side of it (about 20 acres). ut no person has the right to stake out a claim or to mine it who does not st obtain a miner's license, for which the fee is $5, and pay a year's rent for claim at the rate of $1 per acre. A license is renewable only upon payent of the fee and of the annual rent for a claim, and the tenure of a claim epends besides on stringent working conditions. Adequate provision is ade for the protection of miners' rights in a division, and for the enforceent of law and order under the authority of an Inspector.

Miner's license.

Inspection of mines.

The fourth part of the Act is chiefly designed to provide for the health, fety and well-being of miners through a proper and careful observance of gulations for the working and management of mines; but as these follow etty closely the British Mining Regulations any enumeration of their atures would be superfluous here. The Inspector, whose duty it is to look ter their enforcement, finds that owners and officers of mines are with rare ceptions desirous of doing liberally all that the regulations require, and it es not appear that the employed classes have a grievance under them for hich legislation could effect a cure.

REPORT OF THE INSPECTOR OF MINES.

To the Director of the Bureau of Mines:

Sir,—I have the honor to submit herewith my third annual report on the Inspection of Mines for the Province of Ontario, being for the year 1892.

General condition of the mining industry.

Although mining operations have not been conducted throughout the Province on as broad a scale as could be desired, yet in some of the classes of minerals encouraging results may be traced, especially in gold, nickel, copper and mica.

Several of the hitherto large-producing silver mines west of Port Arthur have been closed down, not by reason of having become non-productive, but from causes which may but temporarily suspend the work. The phosphate markets have been dull, and on this account several of these valuable properties have been lying idle during the year, while others have been worked only to a limited extent.

GOLD.

In Lake-of-the-Woods region.

The Sultana and Sultana Junior mines.

The Sultana mine is situated eight miles from Rat Portage, on the Indian reserve, location X42, and is owned by Messrs. John F. Caldwell of Winnipeg, holding fifteen-sixteenths, and H. Henessy of Rat Portage, one-sixteenth. Mr. Caldwell holds the mineral claim X43 Indian reserve and B38, comprising 40 acres. Mr. W. M. Caldwell has the management of the property. A few men were at work from the beginning of the year, and in March the force was increased to 8, who had been constantly employed up to June, the date of my visit.

The place of working is near the landing or dock, and the ore is removed from the opening in wheelbarrows to the place of shipment. An open cutting has been made to the distance of 250 feet in a northeast direction, following the side of the lake, and has been worked to the depth of 15 to 18 feet, showing a width of vein of 27 feet. The lead has been traced between granite and slate a distance of about 20 chains. The lowest cutting is only 5 feet above the high-water mark of the lake. About 130 tons of ore had been mined and removed to the dock ready for shipment to the Reduction Works at Rat Portage. Other openings had been made in the property the fall previous. One which I especially noted is about 500 yards in a southerly direction from the present workings, on a steep elevation, and from which 350 tons of ore had been mined and taken to the mill at Rat Portage. A comfortable boarding-house, a blacksmith shop and convenient docks have been built. It was intended to put on additional force and use steam power for drilling and other purposes so soon as the ore could be properly treated at the mill in the town.

A force of 32 men was employed at the mine and mill at the close of the year. Mr. Margach of Rat Portage in a recent letter states that a stamp mill with rock crusher for pulverizing and Frue vanners for concentrating the ore, is in successful operation at the mine. I note also by a late communication through the papers that a fine gold brick has been turned out of the works as proof of the value of the ore and the successful method of treating it. On Sultana Junior six men were then at work.

The Northern Gold Company's mine.

The Northern Gold Company, formerly known as the Gold Hill Company, are engaged working their prospect, which is situated on the mainland twenty miles southeast of Rat Portage, and contains 906 acres held in fee simple. This discovery was made eight years ago by Mr. George Dulmage, the present superintendent of the work. D. B. Burdette of Belleville is president, and J. R. Wright is the business manager. Ten men had been employed for the past year and their number was increased to thirteen when I visited the property. The workings consist of a shaft sunk to the depth of 28 feet, with other openings following the lead for at least a mile. Shaft No. 2, the present place of working, has reached a depth of 45 feet at an angle of 45 degrees, following the mineral between well-defined walls. The vein matter is 9 feet in width, with about 3 feet of pay streak.

The Leede process adopted.

A carload of the ore taken from these workings had been sent to Minneapolis to be tested by the Leede process, and so satisfactory was the trial that an order was given for a plant to be put up at the mine, although formerly stamps and other machinery of the ordinary class for a mill had been ordered; these were abandoned. The whole of the plant for the new process was expected to arrive and be placed in position for work in a month or two. The boiler is of 40 horse power. The ore will be roasted by gas generated from petroleum, using 12 barrels daily. About 150 to 175 tons of ore were ready for treatment, and by the Leede process this ore will be reduced to bullion. A tramway is now being constructed from the mine to Moon bay, a distance of 1½ miles, which will be in use shortly. Through a reliable correspondent I am informed that 24 men were working on this property at the end of the year.

Homestake mine, on Yellow Girl bay.

The Homestake mine is on a strip of the mainland at Yellow Girl bay, about 25 miles in a southerly direction from Rat Portage, and is owned by the Homestake Company of Algoma, with capital stock of $300,000, in shares of $1 each. About 65,000 shares have been disposed of, and the proceeds are to be used for development purposes and constructing a mill at the mine.

Mr. Heldrith, a member of the company, is manager of the works, and at the time of my visit had mined about 50 tons of ore, 25 of which had been taken to the Reduction Works at Rat Portage. He had a contract to deliver 1,000 tons at Rat Portage, which he expected to accomplish at the rate of 30 tons daily. The proceeds are to be used for the further exploring and developing of the property.

A letter in January, 1893, from William Margach, Crown timber agent, states that "ten men are at work on the mine, and Messrs. Heldrith & Chadwick have a stamp mill which they propose putting in operation."

The Dead Broke mine.

The Dead Broke mine is located on P64, Red Rock island, about 22 miles in a southerly direction from Rat Portage, and is owned by Jeff. Heldrith.

Work on this mine was commenced in April last with ten men, and the vein has been stripped 50 feet in length and nearly the same in width. An open cut has been made 20 feet in length and 12 feet in width and a few feet in depth, from which about 75 tons of ore have been removed, and showing by frequent assays from $7 to $133 per ton; 25 tons of the ore have been taken to the Reduction Works to obtain a mill run. The work was interfered with by the inflow of water, and a new opening has been made at the distance of 130 feet from the former one and the tunnel has been driven in 25 feet. It is intended, I was informed, to put on an increased force and work the property on an extensive scale.

Gold Creek mine, near Pine Portage bay.

The Gold Creek mine is situated near Pine Portage bay, one mile from the point at the head of the bay. The location comprises 180 acres P347, and is owned by Messrs. E. H. Kendell, Samuel Whiting and Joseph Thompson, all of Rat Portage. The discovery was made in 1890; work was commenced en men in the fall of 1891, and has been continually carried tion of G. F. Ernst, who has had large experience as a miner s the property under lease. A vertical shaft has been sunk feet, following a vein with average width of 9 feet from bottom of the shaft. The shaft is well timbered to a rough the clay and sand, where a firm slate formation has well defined walls requiring no supports. Two test pits ne 8 feet on a vein of 10 feet in width, and the other 16 feet er of 14 feet width. The vein has been followed on the s at intervals for the distance of 500 feet west, and in a for 2,000 feet. A force of seven men was employed at it in June.

Extent of the workings.

s of ore had been taken out and was being conveyed by tug Works at Rat Portage for treatment. The place of ship-'s point, a distance of one-third of a mile from the mine, t dock has been built. The ore which was being shipped the dock in the winter season. A good roadway was being he mine to this dock.

g-house and shaft-house have been built, and the whole of out this mine has been done in an exceedingly neat and sub-

Ontario Mining Co.

m Rat Portage, and near Sultana island, the Ontario Mining cation on which a shaft has been sunk to the depth of 50 feet, nt samples of ore have been taken. The property is owned g capitalists.

Winnipeg Consolidated.

Consolidated Gold and Smelting Company own a property on miles out from Rat Portage. Several years ago this property e year. A shaft was put down 120 feet and drifts run in with lts that a stamp mill was put up. The ore was of good grade.

Pine Portage mine.

age mine is situated one mile inland from Pine Portage bay, niles from Rat Portage. A shaft has been sunk 120 feet and rifting done. The property is regarded as valuable and a upon it. Mr. Dobie, one of its chief owners, stated that it would be resumed during the present year.

Climax mine.

ine, owned by A. Egan of Winnipeg, is situated on Big 10 miles from Rat Portage. From an open cut in the side 700 tons of ore have been raised, most of which has been ction Works at Rat Portage for treatment; 36 assays showed of ore to be $19 per ton.

Keewatin mine.

mine is situated on Hay island, 10 miles from Rat Portage, islands of Lake-of-the-Woods, which may be regarded as a t is owned by Good & Jones of Winnipeg.

Heenan mine.

mine, which is one mile south of the Keewatin, a 50 foot k; it is the property of the owners of the Keewatin mine.

Boulder Island mine.

and, containing 12 or 14 acres, a discovery was made a few erable amount of development work done, and a mill put up, rds moved to the Consolidated mine. The property is owned ns and others of Winnipeg.

Fish Island mine.

d, near to Boulder, a promising discovery was made seven property was obtained by a company of capitalists from Cali- to a limited extent. One shaft was put down 30 feet, when ended for the same cause as on the Boulder and other proper- itle.

El Diver, Caribou and Treasure mines, near Rossland station

The El Diver mine is on location P351, which comprises 80 acres and is situated $2\frac{1}{4}$ miles north from Rossland station, Canadian Pacific Railway, 8 miles east from Rat Portage. The property is owned by Messrs. J. W. Webster and E. W. Gaylord of Cleveland, Ohio. Mr. Gaylord has charge of the works at the mine.

Work was commenced in October, 1891, with a force of five men, which was increased to seven during the winter. Ten men were employed in June at the time of my inspection. The principal shaft has been sunk to a depth of 60 feet, following the vein matter from the surface with an average of two feet of pay ore. The work was being done by contract, and about 200 tons of ore were on the dump.

A mill for concentrating the ore has been erected, and the machinery would be in place and all running in about a month. The concentrates were to be treated at the Reduction Works in Rat Portage. It was intended to continue operations both at the mine and mill with a sufficient force to fully test the value of the mine, and to increase the work as the development would warrant. The owners hold the property with a view of working it, rather than as a speculation. A dwelling house with office was being constructed, and a good boarding-house and blacksmith shop have been completed. Other prospecting was being done on the property. I directed the attention of the manager to some necessary work to be done for the protection of the workmen in walling off the ladder-way in the shaft and timbering near the surface.

Mr. Webster also owns P288, comprising 80 acres, known as the Caribou, about half a mile from the station, upon which some development work has been done with excellent showing of mineral.

The last of October I received a communication from Mr. Gaylard stating that the necessary work for the safety of the mine had been properly done, also that the shaft had been continued to the depth of 75 feet, and a shaft house was being built. A friction power hoist has been purchased from the Jenkes Machine Company, Sherbrooke, Que., which will be run by rope belt from the mill. The mill building has been increased to double its size and the mill dam raised, greatly increasing the supply of water for power. The dwelling house with office have been finished, an ice-house built, and also an additional barn and stabling accommodation.

The pulverizer which was on hand when I was there has not proved a success, and a Crawford mill has been put in in its place. It was intended, Mr. Gaylord writes, to push the work forward throughout the winter both in mine and mill if water supply and weather should permit. He also writes: "We have purchased a property two miles south of Rossland (80 acres) known as The Treasure. The ore there carries free gold in abundance at the surface; we are down about 28 feet. The showing at the bottom is not as good as at the top. The vein measures from 2 feet to 6 inches wide. We have erected several log buildings, such as boarding house, blacksmith shop, ice house, barn, magazine, etc. We intend to push the work on the shaft this winter, but shall not erect a mill before spring."

The Gold and Silver Reduction Works at Rat Portage.

About the middle of June I visited the Gold and Silver Reduction Works in the town of Rat Portage. The capital stock of the company is $200,000, with about one-half this amount paid in and used for the construction and outfit of the mill. Charles Brent has the superintendence of the work and J. P. Larkins of Rat Portage is the secretary of the company. Through the courtesy of these gentlemen I had an opportunity of carefully examining the works, and obtained through the superintendent a full explanation of the process being adopted in the extraction of the precious metal from the ore. The mill had just started up and about nine tons of ore were running through daily with the exception of being treated in the chlorination department, which was not yet fully completed. A large quantity of ore was being

dock at the mill for treatment, and it was expected a full
obtained from the mines operated in the vicinity to keep the
running. I forego giving an account of the mill taken at
isit, as by the favor of Mr. Brent the following note has been
describing the process, results, changes and prospects of the
s and other mills, and the condition of several of the mines,
rmitted insertion here as a matter of much information and
rent writes :

Change of proprietorship.

eduction Works, I regret to say that we shut down in August
g to the fact that the pulverizing machinery proved useless.
was as follows : The ore (gold) is crushed wet to 40 mesh,
racted on plates and by pans and settlers ; the tailings from
ntrated. The concentrates were roasted in a reverberatory
ted by chlorination.

o be able to inform you that a wealthy American syndicate
he Reduction Works and will put in new and suitable
operly reduce the ores of this district.

General prospects of the Lake-of-the Woods mining territory.

nines : things look very favorable at present, and if appear-
rusted a boom in mining will take place in the spring.

fall I put in a 10-stamp mill at the Sultana, which is in
ion and is a dividend payer. I am sorry to say however that
en done in the shape of mining development. The machinery
t to bring the ore to the mill ; a 7 by 10 Blake crusher ; 10
unds each in two batteries of five stamps each, with inside
d 12-foot electro-silvered copper tables. The tailings are
ntration over two improved Frue vanners.

sent in charge of the mill at the Bulldog. We are putting
awford mills. The company is pursuing a policy of vigorous
rk and at present (50 ft) the mine looks well.

neighbors at Gold Hill have completed a new mill to be
Leede process. This is a process of roasting by gas manu-
ude petroleum, followed by amalgamation in pans, gold plates
amators.

asure, south of the C. P. R. at Rossland, they are sinking
ects, and will put in a mill in the spring.

Diver a Crawford mill has been put in place, but they are
r. They are sinking with fair prospect of success.

Mining Co., an English syndicate, is operating on a piece of
les from Rat Portage, in a northeast direction.

n Mining Co. is sinking a shaft about five miles north of

estake Co. is sinking a shaft on Middle island with good

ount of prospecting will be done as soon as spring opens."

In the lake Superior region.

The Ogema mine, in Dorion township.

mine is situated in the new township of Dorion, about 8 miles
ling, C. P. R., 40 miles east of Port Arthur and 7 miles east
tation, which is the post and express office for the company.
Mining and Smelting Company was organized under the laws
nd Ontario, with a paid up capital of $150,000. The pro-
400 acres. Mr. John C. Smith, one of the shareholders, is
company and has charge of the works at the mine. Work
ued since September, 1891, when it was begun with a force of
creased to ten at the date of my visit, June 25th. A good
the company in assisting to build the Government road lead-
irection of the mine, and hauling in machinery and supplies

Character of the vein.

In addition to considerable surface workings a shaft of 8 by 10 feet has reached a depth of 50 feet, following the lead of galena and gold ores from the surface to the bottom. The vein is the full width of the shaft at the place of working. The sinking is still in the overflow, the formation being eruptive. The gangue consists of granite, soft trap, amethysts and quartzite, intermingled with fluor and heavy spar, and carrying numerous pockets or deposits of gold carbonates assaying as high as $668 in gold and $8 in silver. Large quantities of galena are found in the workings, some assaying 65 per cent. with $7 50 of silver. The carbonates are put in barrels and a considerable quantity of ore in the rock was lying on the dump.

The mine is provided with a good outfit for convenient and rapid working, consisting of one 15 h. p. boiler and one 12 h. p. engine, a Copeland & Bacon hoist machine, machine drills, steam pumps, etc. A pony saw-mill has also been erected to cut the lumber and fuel required at the mine.

Suitable buildings have been constructed ; shaft-house, engine-house, blacksmith's shop, cooking and sleeping camps ; also a superintendent's residence with office attached, a warehouse and stabling sheds for horses and implements, and a magazine. The mine was in a good and safe condition.

Failure of the Crawford mill to treat the ore.

In a communication received from the manager of the mine since the close of the year he informs me that the mine is still being vigorously developed, although work has been suspended for a short time on account of the extreme cold. Two shifts of men were to be put on almost immediately. In reference to the Crawford mill he writes, "Owing to the immense amount of oxide in our ores the Crawford mill did not give good results. It is a well-known fact that amalgamation is prevented by oxides, particularly that of iron. The Crawford mill however is the most perfect pulverizer and amalgamator I know of, and I believe is doing a grand work on the free milling ores at Rat Portage." He also states, "We have increasingly strong indications of a rich deposit of gold and silver."

In East Algoma and Nipissing region.
Ophir mine.

A large amount of prospect work has been done on the property known as the Ophir mine, north of Thessalon, and very excellent results obtained. Specimens of nuggets have been widely distributed among mining men. Rare specimens I learn have been forwarded for the Columbian Exposition at Chicago. The property has been acquired by a syndicate of Duluth capitalists.

The Creighton gold mine.

The Creighton gold mine is situated three-quarters of a mile from the Vermilion river, in the township of Creighton. It is being worked by an Ottawa syndicate, of which Mr. Seybold is president, and the work on the property is under the direction of J. R. Gordon, C.E. Two lots, 11 in the fourth and 11 in the fifth concession, have been located and development work has been done on both. When at the mine the last of June a shaft had been sunk 50 feet at an incline of 40 degrees, following the vein from the surface. The outcropping quartz-bearing gold could easily be traced for 500 or 600 yards south, and at a width of 250 to 300 feet. The vein matter at the place of working is about 15 feet wide and contains gold of the value of $12 to $20 per ton. A 20 h. p. boiler and a 15 h. p engine are used for running the steam drill, and a Pulsometre pump discharging when operated a 2½-inch volume of water. Six or eight men were employed when I was there.

A good road has been built from the mine to the river, down which the chief supplies for the mine are brought, and a comfortable log building has been put up for boarding and lodging the men.

Balfour mine.

I visited the property of George Bennett of Chelmsford on May 30th, which is 4½ miles from Chelmsford station on the main line C. P. R., west of Sudbury 12 miles.

This property is on lot 6 of the first concession of the township of Balfour, and was being worked for gold and silver by a few men. A shaft had been put down 13 feet and drilling 35 feet from the bottom of the shaft. About 200 feet from this place another boring has been made to the depth of 35 feet. The surface formation is slate, with quartz underlying.

Assays have been made of ore taken from the surface and from the bottom of the shaft, and also from the deeper borings, showing from $2 to $8 of gold and from $1 to $5 of silver per ton. A good level road has been built from the station to the mine.

Rabbit lake location.

A gold property was located in the fall of 1891 about 20 miles east of Sudbury, 13 miles northeast of Wahnapitae station on the Canadian Pacific Railway, and 6 miles east of Wahnapitae lake near lake Kookogaming or Rabbit lake. The discovery was made in a swale, where in drift boulders free gold was found in the form of small nuggets. The property was obtained by Colonel Shaw, A. McArthur and others of Toronto, who engaged Peter McKellar of Fort William to examine and report upon the property. Mr. McKellar traced the boulders to their place of origin, a distance of only 200 feet, where several segregated veins were found. An assay test made from one of these veins by Mr. McKellar showed as high as $2,400 per ton of coarse free gold. Frequent assays showed quantity, from traces to the amount named. Other large well defined veins are found upon the same property which show free gold at the point of exposure, but are chiefly uncovered.

It is intended to prosecute further work at an early date to test the value of the property and, if satisfactory, operations will be commenced on a large scale and suitable machinery introduced for efficiently working the mine.

From the present indications Mr. McKellar, who gave me the foregoing description, regards the property as one of encouraging promise.

Nipissing mine.

A mine containing some gold and silver was discovered in 1891 by A. D. Cummings of Nipissing on the south shore of lake Nipissing, about two miles west of the mouth of South river. A limited amount of prospective work was done in the early part of the year by John McAree, P.L.S., at the instance of A. A. Wright, 273 Chestnut street, New York. The work done was in making excavations at several points on the vein and in sinking a shaft 6 by 8 feet to a depth of 35 feet. The vein is about 20 feet wide, and the gangue consists of quartz, country rock and gneiss.

To fully test the value of the property Mr. McAree writes that the shaft will have to be sunk much deeper; "that there is a good strong fissure vein admits of no doubt."

In the Hastings mining region.

Belmont mine.

In May six men were engaged in working in the Carscallen shaft of the Belmont mine, in the township of that name, which had reached the depth of 100 feet, being 25 feet additional since my last report. The gangue matter contained about 15 per cent. of suphurets. At 70 feet a level has been run in a short distance, and a cross-cut shows the vein to be 15 feet in width. In the O'Neil shaft additional sinking of 10 feet has been done, making this shaft 34 feet and showing a similar grade of ore as that taken out previously. A few additional feet in depth has also been made in the Strickland shaft. The four Crawford mills set up in the village of Marmora had been run at the date mentioned to the extent of treating 220 tons of ore taken from the mine, which ore was found to be highly refractory, carrying iron and copper pyrites. The results as given to me showed a saving of 98 per cent., the assays indicating but traces of gold in the tailings not to exceed 2 per cent.

Process of treatment.

In the process of treatment the ore is passed through a Gates crusher and then introduced to the top of the mill by an automatic feeder in a continuous stream. It is there pulverized by nine balls of about 75 pounds each, which are constantly kept in rapid motion by a revolving disc which produces both a circular and lateral revolution, and by which the ore is ground to an impalpable mass, completely disintegrating the gold from the rock, which then settles into the trough or sink at the bottom of the mill and forms an amalgam with the quicksilver, which has been supplied to each mill to the extent of 125 lb. There is a constant stream of water injected into the mass at the bottom of the mill, which flowing over the disc serves the double purpose of keeping the quicksilver pure and causing an overflow about two feet above, carrying with it the pulverized silica or quartz and other impurities and leaving below the precious metal. The ore is reduced to a fineness to allow of 60 per cent. to pass through a 200 mesh, 80 per cent. to pass through a 120 mesh, and all to pass through an 80 mesh screen. The loss of quicksilver in the test run was 2 lb., the entire quantity used being 500 lb. for the four mills. By the ordinary process of retort the gold was run into a brick and the standard reached 92½ per cent. of gold and a small percentage of silver.

The Crawford mill a success in treating Belmont ore.

In August, at the time of my second visit, the mine was not being operated. In a letter recently received from A. W. Carscallen, M.P., he says: " The Belmont mine is in full blast with a large Crawford mill running night and day, and a second one to be added shortly. They have about 30 men employed and everything is moving lively. The vein as it increases in depth is increasing in richness, and the outlook for this property is very bright indeed. I think the shaft is down about 120 feet, and they have started levels at 30 and 70 feet. The property is being worked by Middleton Crawford, the inventor of the mill, who is getting things in shape so that it will be a most convenient and economically-worked mine. The Crawford mills have fully come up to my expectations, and are now fairly well introduced into Ontario, both here and in the Rat Portage district, where there are three large mills at work now. A number more have been ordered for spring delivery, and the prospects are very bright for both mines and Crawford mills the coming summer. There are no other properties being worked in this section just now, but some capitalists have come in and purchased lithographic stone, and are getting ready for operations as soon as the weather gets warmer. The chances are that there will be a great boom all along the line in mining next summer in this and other sections."

Other gold property in Belmont.

T. D. Ledyard of Toronto, dealer in mines and mineral lands, writes that " gold has been found in several places on the east half of lot 19 in the first concession of Belmont. This lot is adjoining the one on which the new Belmont gold mine is situated.

Gatling mine.

The Carter-Walker process.

I have been informed that the Hastings Mining & Reduction Company have six men at work on surface ore of the Gatling mine; also that a mill is under construction at Marmora village for the treatment of ore by the Carter-Walker process, which consists in crushing and roasting the ore and forcing vaporized mercury through the pulp, which is afterwards treated in settlers.

The Crescent mine.

The Crescent mine was lying idle throughout the winter, but re-opened early in June. At the date of my inspection, August 10th, forty men were employed at the mine and mill. George McDougal had the management, with Wm. McDougal as assayer. J. N. Baker of Nova Scotia had the charge of the mill.

Work was continued on the Mackenzie shaft, which had reached a total depth of 65 feet in barren rock, crossing a vein of ore however at the depth of 50 feet.

The shaft now known as the A shaft was being worked with a few men, in contact with good ore. A considerable quantity of ore was being taken from the large open pit, where the principal work was being done.

The mine is being worked with care, and apparently it is in a safe condition for the workmen. An open pit near the mill required fencing, which the ıld be immediately attended to. The mill had been running days previous, and was treating about 20 tons of ore in 24 ription of mine see former report.

f ore had just been treated in one of the Crawford mills, but ıad not been finished, and the results were not known when e.

SILVER.

Murillo and St. Joseph mines.

mine as well as the St. Joseph mine on the adjoining lot have during the year. For description of properties, see former

Beaver mine.

ıine suspended operations both in the mine and at the mill last visit in July, 1891. A watchman has the care of the

Badger mine.

the Badger mine in June a few men were employed unwatering and doing a small amount of work by way of refitting some l places. The suspension of work on this mine, so largely mer years, as well as the Beaver, I was informed was not for ies of ore, but must be attributed to other causes, the chief preciation of silver. See former report.

Climax mine.

amined the Climax mine, which is on mining location T 145, of the Porcupine and about 1½ miles from Silver Creek Port Arthur, Duluth & Western Railway, to which a good een built. The property is owned by capitalists of Minnea, no company having yet been formed. J. H. Sinclair of ɔ resides at the property, has the entire superintendence of re are two parallel veins on the property, running 30 degrees 300 feet apart. The mine has been worked constantly since ber, 1891, with a force varying from 6 to 13 men. Previous ners purchasing the property some development work had king two shafts to the depth of 34 feet each, one on each nning in a drift on the No. 1 or south vein about 80 feet. s run in on No. 2 or north vein 35 feet.

Extent of the workings.

esent management the level on No. 1 vein has been continued feet, making its total distance 208 feet and following the place of its intersection at 50 feet from the mouth of the ıg the vein 158 feet. At a vertical depth of 31 feet from the her level has been driven in 135 feet, exposing the vein for a et. In the first level, at a point 50 feet from its entrance, a ınk 31 feet to intersect the level below.

2 the old level was continued a further distance of 40 feet, 75 feet from the entrauce and following the vein the entire rtical depth of 30 feet from this level another one was driven wing the lead for 123 feet. There is a valuable showing of

gs are in slate formation, and the gangue consists of calc and ite, sulphide of iron and zinc blende, holding leaf and black ıll portion of galena. A force of 10 men was employed.

West Silver Mountain mine.

ey informs me that West Silver Mountain mine has been closed account of the death of Mr. Drake, the owner of the propxpected work would be resumed so soon as the necessary ld be made with the estate of the deceased. At the time work ıaft No. 2 had reached a depth of 142 feet.

d level drifts had been extended to the distance of 364 feet t east. Drifting in the first level, which is 37 feet from the surface, had been continued to the extreme distance of 151 feet west, and at a point 125 feet from the shaft a winze had been sunk to the level below.

Since my last report but little work has been done in the lowest level. A considerable quantity of valuable ore had been taken out of the mine and shipped. Mr. Rapsey states in a recent letter that "the mine never looked so well as when shut down."

Gopher mine. Discovery of the Gopher mine was made about two years ago by I. S. Roberts on the south half of lot 11 in the fourth concession of the township of Strange. The property is owned by a number of capitalists of Minneapolis, and the company formed is known as the Gopher Gold and Silver Mining Company. Capital stock, $100,000, all paid up. Mr. Howard of Minneapolis is the managing director; office, 707 Globe building. Mr. Roberts has the superintendence of the work at the mine.

Work was begun a year ago last April and continued until Christmas with from 6 to 9 men. One shaft was sunk 104 feet on a vein of 10 feet in width, and at 50 feet from the surface a drift was run in 52 feet on the vein and a cross-cut of a few feet was made. Assays from these workings show value of the ore running from $5 to $60 per ton. At a distance of 250 feet from the first, a second shaft was put down 20 feet on vein matter. No. 3 test shaft was sunk between the first and second 21 feet, in which was found a good showing of native silver.

The machinery consists of one 20 h. p. boiler, a 10 h. p. engine and a pump; but so far the pump had not been required for use.

An engine house and good dwelling house, blacksmith's shop and drying room for the men have been put up. It was expected work would be commenced again about the first of August.

Augusta mine. Work on the Augusta mine was suspended in November, 1891. Since the former report about 60 feet of drifting has been done and a shaft 12 feet deep sunk at a distance of 130 feet from the mouth of the last drift opened. In this shaft it is said good ore was found. Mr. Griffis, the manager, informed me that the property would be worked again about the first of September.

Mines lying idle. Silver Bluff mine was lying idle. Mr. McEwen, the manager of the Shuniah Weachu or East Silver Mountain mine, informed me that work had been discontinued at this mine October, 1891. No additional work except exploring had been done since last report. Silver Bluff, Crown Point, Silver Centre and Palisades mines were also lying idle.

Guaranty mine. Mr. McEwen has charge of a new property known as Guaranty mine, comprising 160 acres, situated on the fourth concession of Strange, six miles east of Silver Mountain. It is owned by a company in Minneapolis; capital stock $150,000. I found 12 men employed under Captain James. A vertical shaft has been put down 45 feet on a quartz vein. Boiler and engine 16 h.p., with suitable hoist. An engine house and comfortable boarding camp have been built.

Empire mine. The Empire mine location comprises 135 acres, being lot one in the second concession of O'Connor, and adjoining the Beaver location. Work was done as early as 1889 by sinking a test shaft 14 feet on the north part of the property. An opening was also made in the hill side on the south part of the location, opening a promising vein of ore, and a shaft was sunk 14 feet. North of this opening, 112 feet, a shaft has been sunk 16 feet deep, exposing good ore, and west of this opening another shaft has been put down 26 feet. Work has been retarded on the property on account of inflow of water. This mine gives an exhibit of very rich ore.

The property known as RXX mine is situated in the township of Scoble, comprising 80 acres. It is about 25 miles west of Port Arthur, adjoin ing Rabbit Mountain, and is owned by Joseph Brimson and R. E. Mitchell, both of Port Arthur. This mine, which is due south 1¼ miles from the famous Beaver, has been worked since November, 1891, and had a force of seven men employed when I was there. T. R. Walker of Port Arthur has the management of the work. RXX mine.

A vertical shaft 7 by 10 feet was sunk to the depth of 98 feet, following the vein, which is from three to four feet in width, evidently being a tracer of the Beaver vein, and showing silver which becomes richer at the bottom of the shaft. The shaft was still in the trap rock, but the slate formation was expected to be reached at an additional depth of from 15 to 20 feet. Hoisting was done by a whim. A boarding house, sleeping camp, dry house, stabling and a blackshith's shop have been erected.

Upon examination of the Lily of the Valley property, which I visited on June 14th, I found that two distinct veins of ore had been opened and traced for a distance of about 50 rods. Their course is east and west. Lily of the Valley mine.

Starting at the farthest point east, the two veins are about 300 feet apart. The north vein runs due west and the south vein north of west, so as to form a junction with the other vein at a point 50 rods west. The first discoveries were made on the two veins nearly opposite each other, and about midway between the two extremities. A shaft was sunk on the south vein a little west of the place of discovery to the depth of 20 feet, showing the vein between well defined walls to be three feet in width. At a distance of 200 feet east of this shaft, on the same vein, another shaft has been put down to the depth of nine feet. The first five feet passed through clay, when rock consisting of spar and quartz was reached. The four feet of sinking in the rock showed the vein to a width of six feet. Work was being done in this shaft at the time of my visit.

On the north vein, which is now designated the main vein, and nearly opposite the first shaft, a third shaft has been sunk to the depth of 30 feet, exposing the vein to a width of 10 feet, but the full width had not yet been determined. The mineral has been followed from the surface to the bottom of this shaft. Work had been suspended on this shaft for two months, and it was partly filled with water. At this time about 20 tons of high grade ore had been taken from the mine.

Since writing the above, a recent note from Mr. Hugh Munroe, Crown timber agent at Port Arthur, informs me that a shaft has been sunk to a depth of 25 feet, with a showing that is really good. He states, "I saw ore that would assay $7,000 per ton."

I have been informed that the main vein has been traced by surface working a distance of three miles east and 1½ miles west.

COPPER.

In the early part of June I visited a property formerly owned by the Montreal Mining Co. on Point Mamainse, which is on the east shore of lake Superior, about 60 miles in a northwesterly direction from Sault Ste. Marie, and I spent some time in examining a part of it. It consists of two locations, one known as the Sand Bay location, comprising 6,400 acres, and the other as the Pancake Point location, comprising 4,800 acres; a total of 11,200 acres. The property has passed into the hands of Detroit capitalists, who hold it by option, and they are engaged in doing development work under the direction of Captain T. H. Trethewey, who has had extensive experience in mining. It may be of interest to submit an extract or two from the report of this property, which Mr. Trethewey, after careful exploration made to Mr. H. S. Sibley, trustee, of Detroit. The description he gave is as follows: Copper locations on Point Mamainse.

Description of the properties.

"The formation is that of the copper bearing series, being identical with that of the Keweenaw copper-bearing rocks, and no doubt will prove a continuation of the same, consisting as it does of an enormous development of beds of alternating amygdaloid, trap, conglomerate and other allied rocks. It commences at a point on the shore of lake Superior northerly from the north boundary of Sand Bay location, and forms a chain of high hills about 3½ miles wide extending in a southeasterly direction to and beyond Pancake river, and includes also the northeasterly portion of Pancake Point location, the southerly portion being of the same formation but low and flat. The amygdaloid beds are from 3 to 20 feet thick, the trap beds from 10 to 300 feet thick, and the conglomerates range from 400 to 500 feet or more in thickness. The latter contain water-worn quartz boulders and pebbles, varying from that of coarse sand to boulders 15 inches or more in diameter. The conglomerates in which native copper occurs have not these large boulders, but are from 4 to 14 feet in thickness. The strike of these beds is from the northwest to the southeast, and they dip at an angle of 20 to 30 degrees to the southwest towards and under lake Superior, similar to the Keweenawan series on the south shore; but further inland they may be more tilted, as the beds from which I took the dip were on the lake shore.

The occurrence of copper in veins.

"Copper occurs in this region in different forms of deposit. First, in true fissure veins from three to ten feet wide, which have a north and south strike, and an easterly dip sometimes cutting the formation at an angle of 45 degrees and generally faulted, the foot wall having a lateral thrust southward. The gangue consists of earthy calcareous spar, fluor spar, druzy quartz, epidote, chlorite and brecciated fragments of the adjoining rock, in which is concentrated not only native copper but in some of these lodes copper pyrites, copper glance, green carbonate, red oxide, black oxide and native silver. Sometimes the latter is associated with the native copper; at other times it occurs on a branch of the vein entirely separate from that carrying copper. The copper glance gave by assay eight ounces of silver to the ton of 2,000 lb. . Secondly, in entirely or partially filled cavities in the amygdaloid beds, and it is reasonable to expect that where the lodes intersect these copper-bearing beds rich deposits of copper will be found not only in the veins but extending for a considerable distance into the beds on each side, and following their dip, as often occurs in the copper mines on the south shore. Thirdly, in small masses and sheets lying between the trap and conglomerate beds as a cementing material, or a portion of a cementing material, occuring as a matrix in some of the conglomerates similar to that of the Calumet and Hecla mines in Michigan.

Course of the veins.

"In following the formation northward from Sand Bay location veins occur, the direction of which conincides with that of the strata; but dip at a different angle, characteristic of those of the Ontonagan districts.

"In following the trend of the strata inland, southeasterly from Sand Bay, it is found to swing round more to an easterly and westerly direction. The veins cut the formation nearly at right angles. Their course is generally marked by a deep depression through the hills similar to that of the Cliff and Central mines in Michigan. Very few outcroppings are seen, the adjoining rock and *debris* having covered them. Small creeks often follow the course of these veins. In these I have found outcroppings which generally showed native copper in small particles, as well as larger pieces up to five inches, from which I have broken specimens with the use of an axe or small pick . .

On the Huronian border.

"At the northeasterly corner of Sand Bay location, about one mile southwest from the corner post, the Huronian slates come in, having a dip to the southwest; they probably underlie the copper-bearing rocks. There quartz in veins occurs, the quartz being copper stained and likely to carry gold and silver. Granitic and syenitic rocks occur farther to the northeast . .

would in all probability be headquarters, where an office, and two dwelling houses erected in 1883 are still in fair

ngs were being used at the date of my visit for the conveni- ager and the workmen. A force of ten men was employed, month of May the expenditure for work and material was he principal work being done was boring with a diamond drill. d been made on four different veins, aggregating a total of llows :

Diamond drill exploration.

No. 1, boring	82½	feet deep.
No. 2, "	110	"
No. 3, "	50	"
No. 4, "	77	"
No. 5, "	99	"
No. 6, "	123	"
No. 7, "	172	"

ose of the year Mr. Trethewey sent on to me a further account e on this property in which he states :

progress of operations in this location during the past year, I in December, 1891, an exploring party was placed at work d drill to demonstrate the character of a number of veins and which displayed favorable superficial indications. After 600 feet at various points, several of which showed native d other ores, the one presenting the most encouragement was vas decided to sink a shaft to fully demonstrate the strength a depth of at least 500 feet. The drill core obtained at a et contained native copper ores of considerable richness. ing the autumn of 1892 a plant of machinery necessary for he shaft proposed was erected at the vein, including a four- ssor, double cylinder steam hoisting engine, boiler, etc., since shaft has reached a depth of 52 feet. For over 40 feet in has produced copper of exceptional richness, both in sheet, small mass and heavy shot form, as well as quite heavy ay of which yielded 34 per cent. of copper and 14.7 ounces of The vein also shows small quantities of native silver. It is he other veins which displayed copper in the cores of the ill receive attention during the coming season, but of course will be concentrated upon the vein which the limited amount proves to be so richly charged with copper.

Sinking a deep shaft on the vein.

of interest to add that the cost of the diamond drilling here, onglomerate, amygdaloid and trap rocks, was $1.92 per foot, the entire cost of buildings, cutting roads, diamonds, etc., pt the drill itself."

Cost of diamond drilling.

COPPER AND NICKEL.

ne when I visited the Copper Cliff mine there were about 400 by the company. The new rock house had been completed as being extensively worked.

Canadian Copper Co's. works.

this mine, with an incline of 40 degrees, has reached a depth about 500 feet vertical depth. Extensive stopes have been urface and down to the first level, 58 feet from the surface. l is 40 feet below the first, and has been run for a consider- good ore. The third level is 83 feet below the second and 100 feet. The fourth level is still 82 feet lower, in which opes have been made and run in 120 feet. The fifth level, below the fourth, has been run in 180 feet and several stopes

Copper Cliff mine.

made. The sixth level, at a depth of 87 feet from the one above, has been run in 250 feet, but little stoping has been done. The lowest level is 86 feet below the sixth, and has been driven in to a total distance of 360 feet and passes through a fine field of ore.

The smelters were run to their usual capacity until within two months of the end of the year, when they, with the work in the mine, were closed down.

The Evans mine.

On the 2nd of July I visited the Evans mine and found 75 men employed, under the efficient direction of Captain Alfred James. The shaft was 220 feet deep. Work had been extensively carried on in the open pit and the three levels below it. A considerable amount of ore was being taken out and the whole work in connection with the mine was being done in a workmanlike manner and proper attention paid to the comfort and safety of the workmen. About the middle of September I again examined the mine and herewith give a more detailed description of the work, as it brings it up to a later date.

Open pit workings.

In the open pit mentioned above, work was being done by 7 men in stoping, trimming and removing rock, and scaling ground. A fine ore body was exposed in the northerly part of the pit of about 30 feet in width, and extending from the bottom to the surface. On the east side of this large excavation there is an extensive field of copper ore, carrying but little nickel. The ore in this mine is sorted into three classes and treated separately, viz: Pure nickel ore, carrying but little copper; pure copper ore, carrying but little nickel; and the nickel and copper combined. The ore is taken back on the tramcars to the hoist shaft and raised to the rock house. Work will be continued in this open pit.

Second level.

A second level, which is 40 feet below the first, has been run in north 100 feet, in which large stopes have been made extending upward to within 20 feet of the floor of the first level. A large centre pillar of ore and side pillars have been left to support the roof of this part of the level. Another drift south has been run in 30 feet, in which stoping has been done, commencing at the shaft and extending back some 20 feet, leaving the opening about 12 feet wide and 12 feet high. The remaining part of this drift is in lean ore or barren rock.

Third level.

Forty-eight feet below the level No. 2 a third level has been run in north 100 feet. Extensive stoping has been done extending 40 feet in width and 30 feet in height, or within 18 feet of the floor of level 2. Three pillars of ore are left as supports in this working. A large body of ore remains in sight in this drift. A south drift has also been run in for 50 feet and an extensive stope made 30 feet wide and 30 feet high, being arched over in the centre for support.

Fourth level.

Level No. 4 is down 57 feet below No. 3. A north drift has been run in 40 feet, and but little stoping done. A south drift on the same level is run in 20 feet, with considerable overhead stoping done. There is a fine showing of ore in this drift.

Fifth level.

The shaft has been sunk to the total vertical depth of 270 feet, and a fifth level run in which is 50 feet below the fourth. Work in this level consists of a north drift extending 18 feet, with stoping just commenced. A south drift has also been driven in 18 feet. A pump has been put in this level of sufficient capacity to lift 150 gallons of water per minute to the reservoir in the third level, at which place another pump of equal capacity makes the water discharge at the surface.

Machinery.

Drilling is done principally by machinery. The Rand air compressor operates the drills and is capable of running seven. The double machine has capacity to run fourteen drills. About 120 tons of ore are taken out in 24 hours. The ore, when sorted, crushed and screened, is conveyed by railway to the roast beds near the smelters at the Copper Cliff mine. There are two boilers

50 h. p. each and two of 70 h. p. Three are in constant use and one is ld in reserve. The hoisting engine is 150 h. p. and two drums attached. ie hoisting is done exclusively on the day shift. Two men are usually ployed during the night in putting everything in proper shape for work the morning. The crushing engine is 50 h. p.

Buildings.

The buildings consist of a shaft and rock house, engine-room and boiler- use, changing-house, blacksmith shop, office and warehouse. A boarding- use is conveniently arranged with 18 sleeping apartments and a large ting-room. Three double frame dwellings with five other residences have en provided for the workmen. I gave direction that a frame that could be nporarily removed when necessary should be placed around the engine and lting in the rock-house.

About 1,800 cords of wood were on hand, obtained from the timber ar the mine.

School accomodations for the children are obtained at Copper Cliff, where ood school is maintained. A Sunday school and religious services are con- cted on Sabbaths in the large dining-hall of the boarding-house. Daily ils come to Copper Cliff, a mile distant.

The Stobie mine.

In the latter part of June I examined the Stobie mine, when a force of men were employed under Captain Bluett. Work in the open pit was ng vigorously carried on, which is now about 85 by 100 feet at the surface l has reached a depth of 70 feet, narrowing as it goes down to the present ce of working. The work will continue both in stoping and sinking in s pit, from which about 100 tons of ore are being lifted daily. The adit el, 6 by 8 feet, has been run in 85 feet in a southwest direction, with large stoping at the entrance. As the rock formation is firm no timbering equired.

Machinery.

Two steam drills were in use, one in the open cutting and the other in drift. In addition to these, three air compressor Ingersoll drills are used. hoist is a steam derrick. The bucket holding 1,200 lb. of ore is dumped o a car and run out on a tramway 120 feet to the rock-house. It passes into Blake crusher, which is capable of crushing 150 tons in ten hours. It is n screened and the three grades, fine, raggins and coarse, taken to the st beds at Copper Cliff for calcining, a distance of nine miles. About cars are loaded daily, being about two-thirds of the entire quantity of ore ated in the two smelters. Three 20 h. p. boilers and engines are used arately for running the drills, hoisting the ore, and crushing and screen- it.

Exploiting the ore body.

In addition to the large body exposed, the ore has materially improved in percentage of nickel. The deposit of ore has been traced along the rise top of the hill in a southwest direction for a distance of 500 or 600 feet. eral test openings have been made along the lead passing through the san, showing fine bodies of nickel ore.

A large quantity of wood is collected at this point and three cars, say ut 37 cords, are taken daily to the roast beds and Copper Cliff mine.

Buildings.

Besides a comfortable residence for Captain Bluett and family, there has n erected a good boarding-house and all other suitable buildings for the k.

The whole is under the general management of Mr. John D. Evans, who des at Copper Cliff.

The workings at the mine present a neat and safe appearance, with the eption of a projecting rock over the mouth of the adit which I directed uld be removed.

Progress of operations.

In September when I again visited the mine the workings in the open had been extended westward under the hill to a distance of 30 feet from perpendicular wall and to the length of 70 feet. As the work would be extended in this direction it would be necessary to leave substantial pillars of ore to support the rock roof. On the east side of the large opening a skip roadway was being cut through the rock, over which the ore could be taken out of the mine and conveyed to the new rock-house which was then being constructed by the side of the railway track. The southwest drift has been extended to the distance of 172 feet from the entrance and running in the direction to reach the ore bodies as shown on the surface, as described before. Apparently there is an extensive field of ore in the mine, and of much richer quality than that obtained in the earlier working of the property. A new engine-house had been built and two new boilers set up of 75 h p. each, with the engines which are intended to give the motor power for all the machinery at the mine.

A recent note from the captain of the mine informs me that the drift has been extended and a raise made opening the ore bodies on the hill.

H. H. Vivian Company.

The Murray mine.

Extension of mining work.

I inspected the Murray mine (property of the H. H. Vivian Co.) on the 28th of June. It had not been worked from the middle of October last to the end of April. The southwest drift in shaft No. 6, at a depth of 60 feet from the surface, had been run in the entire distance of 165 feet, and large stopes had been made in it. Due west of the shaft 35 feet, a winze was being sunk to reach the level below, which was 20 feet deep. The northeast drift had been extended to the entire distance of 250 feet, in which extensive stoping had been done. The north drift at the bottom of the shaft, which is 100 feet deep, had reached the distance of 35 feet, and the small drift mentioned in the former report starting from about the middle of this drift had been run in 35 feet. Another shaft had been started on the opposite side of the railway track at a distance of 400 feet from the former one, in a northwest direction, and had reached the depth of 25 feet.

Work of the smelting furnaces.

The two smelting furnaces, of 50 tons capacity each in 24 hours, were running about 45 tons of good ore daily. The coarse matte produced from the ore is bessemerized and shipped to Swansea, Wales. As shipped the matte is raised to about 40 per cent. nickel and 20 per cent. copper. About four car loads of 15 tons each of Pennsylvania coke was being used weekly, or about eight tons daily. With duty and freight combined it can be laid down more cheaply than the Nova Scotia coke. Cars are loaded at the coke ovens in Pennsylvania and unloaded in the coke house at the mine.

Bessemerizing the matte.

Three boilers and three engines aggregating 100 h. p. were in use, one of 60 h. p. and the others of less capacity. The largest one is used for injecting the air through the metal in bessemerizing it, a process which occupies an hour and a half for each charge of two tons. It is then emptied out into pots where the nickel settles to the bottom and leaves the slag on the top, and when cooled in the pots and taken out the slag is easily broken from the metal. About one-quarter ton of fine matte is contained in each pot. A sufficient supply of ore was on hand to keep the smelters running for three months.

Cordwood fuel.

I was informed that 5,000 cords of wood are consumed annually in the smelting department, including the roasting. An area of 500 acres of wood land is cleared annually to supply this department of the work. The rapid consumption of wood will at not a distant date place these mining companies dependent upon the C. P. R. for bringing in fuel.

Management.

Mr. Harry Edwards has the full charge of the smelting department, in which about 70 men were employed. Mr. H. Lidgey, of Swansea, Wales, is general manager, having recently removed with his family to the mine.

September inspection.

In September I was again at the mine and examined the whole of the underground workings. Percy McNulty, the foreman, had under his charge 30 men who were divided into day and night shifts. Work was being carried on extensively in the first level of shaft No. 6, and in the lower level a small force was working in excellent ore. About 75 tons of ore were taken out daily, and when orted about 60 tons were fitted to go to the roast heaps. A good rock-house vas built and a 10 h. p. engine was used for hoist. Four air compressor drills vere in use. The shaft was neatly and substantially timbered and a convenient adder-way of 12 feet rests extended to the bottom of the shaft. I gave direction that this should be properly walled off from the part of the shaft in which he hoist cage was used.

In the smelting department a new furnace, specially designed by Mr. Edwards to meet the need of the ore and the work, of 140 tons capacity in 24 ours, has been put up and it was expected to be in operation in about ten ays.

When the present smelters are continuously running about 60 tons of ore re treated in 24 hours On account of the short water supply previously there ad been a temporary suspension of smelting, but the furnaces were running to he full capacity at this date. The bessemerizing process was satisfactorily ontinued, raising the standard of the matte for shipment to 40 per cent. nickel nd from 20 to 25 per cent. copper.

A new and convenient office has been built at the smelter, together with a hop for repairs containing lathe, drill, etc.; also a new coke house of 500 tons apacity.

Improvements.

An important improvement has been made in the tramway which leads out the roast beds, in providing suitable turntables at each branch track whereby he ore can be dumped upon the roast heaps. One turntable is used for vo roast heaps, the beds being on both sides of the main track. Thirteen urntables were put in, supplying 26 roast beds. The same are used to eturn the roasted ore to the smelter. A convenient weighing-house is built ver the tramway and all the crude ore is weighed as it is run out to the roast eaps, and the roasted ore reweighed as it is returned to the smelter.

Dominion Mineral Co.'s works.

The Blezard mine.

First inspection.

On the 27th of June a force of 170 men were employed at the Blezard ine (the Dominion Mineral Company's property), 60 of whom were doing nderground work. They were chiefly engaged in removing the rock roof ver the first level, and removing some of the pillars which had been left to ipport it. The work, although somewhat hazardous, had the advantage of eing in full daylight, and was apparently being done with care. A few men ere engaged in stoping in the bottom level in shaft No. 1, in which no lditional sinking has been done. Shaft No. 4, or the new shaft, at a stance of about 50 feet north from the open pit, had been put down an lditional 30 feet, and a 30-foot drift in a northeasterly direction had been iven in. At this time about 150 tons of ore was being taken out daily om the mine, crushed and screened, and sent to the roast beds.

Management.

Captain Robert A. McBride, formerly of the Worthington mine, had arge of the work in this mine, and Mr. Ian Cameron of Glasgow, Scotnd, had the general management of the company's works, having entered on that duty on the 15th of March last. Mr. Cameron has had large perience in mining, and he has also been engaged in refining nickel in ngland, Scotland and Germany.

Serious accident at the mine.

In the early part of September, in company with the Director of Mines, revisited this mine on the occasion of the accident which resulted in the ath of five men and the injury of two others, on which a special report has en made to the Commissioner of Crown Lands. On a careful inspection of e open pit where the accident occurred, the Director of Mines fully conrred with me that no further work should be done on the floor of this ening until the entire remaining roof was removed and the pillars staining it were taken down, excepting that part of the roof supported by e large pillar through which the shaft passes to the deeper workings of the ine, a decision which the manager of the mine himself had arrived at. This ge pillar itself, by the blasting around it, showed some places of seam or broken formation at the sides, and we ordered that firm additional supports should immediately be put in proper position to render it entirely secure. I gave written instructions as to what should be done to make the whole of the work safe, and the manager said they should be complied with at once.

State of the mine at the second inspection.

At this time no additional sinking had been done in shaft No 1, which was something over 170 feet in depth. The floor of the open level at the place of the shaft is 69 feet from the surface. A second level at 30 feet below the floor of the open level had been run, but was in disuse. At a greater depth of 85 feet from the floor of the first level the third or bottom level was run in about 60 feet southeast, which is known as the southeast level. A large stope was made in this drift 25 feet wide, and about the same in height, in the centre of the arch. A cross-cut is run in from this drift at a distance of 45 feet from the shaft, and extending upwards. A drift on the north side of the shaft has been run in 35 feet, but no stoping done in it. A sump is placed in this drift near the shaft, and a pump to hoist the water to the surface. This was the principal place of working in the mine at that time.

In September the new shaft had reached a total depth of 95 feet. At 81 feet from the surface a drift of 16 feet had been run in, and it was intended to extend this drift to connect with the main workings near shaft No. 1. This shaft was properly timbered and a suitable frame put in for a cage hoist. It will become the main working shaft of the mine. One hundred and sixty men were employed at this date, and about 15,000 tons of ore were on hand, together with 250 tons of matte.

The Worthington mine.

The Worthington 'mine is also owned by the Dominion Mineral Company. Although operated to a limited extent formerly, it has had a considerable quantity of high grade ore taken out. Work had been suspended for some time, but was again resumed on a fair scale during the latter part of the year and with most encouraging results. A body of exceedingly rich ore has been discovered in one of the shafts, which is said to be the most valuable of any nickel ore found in that district in quantity. About 50 men were employed on the mine at the close of the year. The company may regard it as practicable to place smelting works at this mine at not a distant date, as large shows of ore are being opened up.

Drury Nickel Company.

The Chicago nickel mine is in the township of Drury I inspected it on the 29th of June. For further description of location see former report. The mine and works are owned by a company of capitalists in the cities of Boston and Chicago, known as the Drury Nickel Company, with Mr. R. P. Travers as president. The capital stock is $500,000, with $120,000 paid up.

Chicago nickel mine.

Extent of the openings.

A large open cut, the principal place of working, has been extended to the full length of 300 feet on the surface, and a fine deposit of clear ore is exposed of from 14 to 15 feet in width, with diorite foot wall. The ore deposit has increased in width about 20 additional feet, but is mingled largely with rock, say about one-half good ore. The width of the open cut at the surface is 20 feet, and at the bottom, at a depth of 40 feet, it is narrowed to 14 feet. The deepest workings have reached 70 feet and are in good ore.

Machinery and smelter.

Across the ravine, about 300 feet west from the present workings, a test pit has been opened which shows fine ore Four air-compressor drills are used in the mine, two Ingersoll and two Rand. The ore is lifted from the mine to the top of the rock house by two skips drawn by two 4 foot friction drums, which are run by a 60 h.p. engine. The ore when hoisted is dumped on the crushing floor in the top of the rock house. When screened the three sizes, fine, seconds and coarse, are dropped into chutes, under which cars holding about two tons each are carried over the trestle tramway and dumped on the roast beds. The tramway can easily be shifted from one roast bed to another.

house is a substantial structure 60 by 60 feet, with an annex Besides the furnace the plant consists of three converters, double cylinder air compressor, one 45 h p. engine, two 85 l two steam pumps. A set of Cornish rolls are used for uartz and other materials for lining cement.

Management.

se is a good building 30 by 50 feet; but there is also a good d saw-mill with shingle mill attached for manufacturing all hingles required for the company's purposes. The laboratory, well fitted up, with Mr. Fred. Edwards in charge as assayist. avers of Chicago was at the mine exercising a general super- ntire work. Captain Travers is superintendent, with Alex. a. A full force of men was employed in the various depart-

Sheppard mine.

l mine is being opened up about two miles north of the ne Sheppard mine, on which a force of 40 men is employed, sion of Mr. E H. Davies, sinking a shaft and doing other k. A good plant is in use, consisting of a 35 h.p. boiler oisting, running a 7-drill Rand compressor, etc.

Macdonald mine.

the third concession of Denison, one and a half miles from ne and three-quarters of a mile from the railway, a property acdonald mine was worked part of the year with a force of 10

Keewatin nickel property.

nd a halt miles from Keewatin, on Lake-of-the Woods, a has been discovered, and some prospecting work has been penings on the surface have been made to a width of 75 ength of quarter of a mile. One opening was made 8 by 20 deep, from which about 30 or 40 tons of good ore have been r men were employed in opening the property for five or six operty is owned by six persons residing in Rat Portage and omprises 56 acres held in fee simple. Assays made by Mr. thur show the ore to be of good grade.

MICA.

Foxton's mine and works.

s Foxton & Bros. of Sydenham are working an amber mica on the eighth concession of Loughborough with a few men. been opened at different places along the surface for the eet, with cuts at the respective depths of 10, 20, 25 and 45 extends over an area of 550 by 30 feet, from which about on taken out. During the two weeks previous to my visit e ton per day had been mined. The place of working was et down from the surface. About half of the mica obtained ty is in large crystals, 10 by 12 inches. It is very tough, 6 per pound, while the smaller size, 2 by 4 inches, is sold at nd. This property is two and a half miles from Sydenham. eported as dull.

ica property owned by the Sydenham Mining and Mica en lying idle during the year.

Smith and Lacey mine.

h & Lacy are still operating their mica property in the ingham, county of Addington, with satisfactory returns of

Grant mine.

nine is situated on lots 7 and 8 in the tenth concession of hree and a half miles from Sydenham. It had been exten- former years, but was idle in May.

The Amy and Folger mine.

The Amy and Folger mine is on lot 8 on the eighth concession of I borough, and is worked by Messrs. Folger and Williams. Six men employed when I was at the mine in May, with Samuel Cordick as for Mr Williams has the general management of the work. One opening been made about 75 feet in length on the surface and worked to a de 30 feet. This vein can be traced on the surface for 200 feet and is feet wide. The mica is found in the limestone and taken out in con able quantity. The largest size is cut to 6 by 10 inches, but the greater p tion is in smaller sizes. Four men were working in this pit. A s working was newly made at 300 feet from the former one. The surfa been opened for 30 feet and worked to a depth of 15 feet in broken form and the rock and mica were being removed chiefly by picks. The m hauled to Sydenham and sold to the Thompson, Houston Co., and is in the cutting works in the town.

Truesdale mine.

The Truesdale mine is on lot 8 in the third concession of Loughbor Three men were employed, and the work had been continued for the pas months. It gives promising returns.

terling mine.

C. I. Sterling of Kingston is operating a mica property on lot 16 ninth concession of Loughborough, about seven miles northeast of Syde The mine had been worked for about a year and a half, but had bee pended for the three months previous to my visit. A shaft had opened 7 by 7 feet at the surface, which widened as it went down to 18 feet at a depth of 70 feet. It is about half filled with water. During months of last year 50 tons of 80 per cent. phosphate and 10 tons of mica were taken out. In the present year, up to the date of my visit in 10 tons of high grade phosphate and 15 tons of mica had been mined.

Mica and phosphate.

The lead has been traced for over 300 yards, and three test pits been sunk from 15 to 20 feet in depth. In one of these pits a vein of feet width has been opened of excellent phosphate, which will be worl soon as the market improves. About twenty other surface openings been made along the lead, showing phosphate and mica. Hoisting is by horse-power. This mine is about eleven miles from Murvale stati the Kingston and Pembroke Railway, to which the phosphate is haule shipment. The mica is taken to the cutting works in Sydenham.

PHOSPHATE OF LIME.

Wolf lake mine and other properties in Bedford and North Crosby.

W. J. Webster of Westport owns a phosphate property on lot 28 eighth concession of Bedford, situated on the border of Wolf lake. Th rises to an elevation of 280 feet, with an incline of 30 degrees. On th side a shaft has been run in 15 feet, tapping a vein 7 feet in width of amber mica. About one ton had been taken out, and it was intend push the work vigorously. If the market improves the work w extended on the phosphate deposits, which have a favorable showing. Webster has also obtained the following phosphate properties : Lot 21 tenth concession of North Crosby, being a continuation of the lead former lot described. On lot 19 in the second concession of North C development work has been done, uncovering a vein of phosphate on in width for a considerable distance. On lot 29 of the ninth concess Bedford prospecting work has been done, and 10 tons of from 65 to cent. grade of phosphate taken out. Also on lot 21 of the tenth conc of North Crosby limited prospecting has been done, showing a good o of high grade ore.

Work at the Opinicon or Rock lake mine was being still carried on the control of Neil Cochran with a force of 25 men at the time of my v May. Charles Pine of Westport was acting as shipping agent. The opening described in my last report at 150 feet depth has been sunk now to the depth of 225 feet. About 150 tons of 75 per cent. ore are being taken out monthly; 800 tons were on hand at the mine. A self-dumping car of one ton capacity is used in raising the ore. A new boiler and engine of 50 h.p. are now used for running the steam drills, hoisting the ore and working two pumps to keep the mine free from water. I directed that the ladderway should be placed on the west side of the pillars, which are left to sustain the hanging wall of the mine, as the workmen would then be entirely free from danger when going in and coming out of the mine; also, that an open unused pit near the roadway should be properly fenced. Otherwise the mine was in a safe and workmanlike condition.

Opinicon or Rock Lake mine.

Lake Opinicon mine is situated in the township of Bedford, and comprises 1,750 acres. It is owned by Mr. Swift of Ottawa, W. H. Davis of Buffalo and others, but the company's organization has not yet been perfected. Eight men besides the foreman, William J. Shales, were working at the mine. It was stated to me that a large force of workmen would be put on when the company was properly organized, which was expected to be accomplished at an early date. The mine had been worked two months in the previous year, and constantly since the beginning of April last. A shaft had been put down 48 feet, and an opening made following the lead for a distance of 136 feet, varying from 2 to 25 feet in width. Eighty tons of 85 per cent. phosphate had been taken out; 45 tons were on the dock ready for shipment, and the remainder was at the mine. A boiler and engine of 30 h.p. were used for hoisting and for driving two steam drills. An engine-house, derrick, stabling and cobbing house have been built. The ladders going into the shaft were in an imperfect condition, so I gave instructions to have these properly placed, secured and walled off from the hoisting part of the shaft.

Lake Opinicon mine in Bedford.

The Foxton mine, the Concession mine, the Johnson mine, the Eagle Lake mine, the St. George Lake mine, Silver Lake mine and Crow Lake mine were all lying idle.

Mines lying idle.

Mr. William Davies of Perth, a gentleman largely interested in mining operations, and a dealer in mining lands, informed me that nothing was being done in that vicinity when at his place in the last of May, except a little prospect work for mica, and that but little work would likely be done until there was a change in the market.

The Perth district in Lanark.

Mr. Sterling owns the Coe mine on the west half of lot 5 in the ninth concession of Loughborough, near Gould lake, three and a half miles from Sydenham. This property had been extensively worked formerly. Last year's output realized 65 tons of 80 per cent. phosphate and 70 tons of second quality, besides a small quantity of excellent amber mica. The force employed was 8 men, with Mr Samuel Cordick as foreman. If markets improve, work will be resumed at once on this property for both minerals.

Coe mine.

Phosphate and mica.

The Otter mines are situated on lot 9 and the east half of lot 11 in the seventh range of North Burgess, the former containing about 200 and the latter 100 acres. These properties are about eight miles from the town of Perth, to which there is a good road, and about two miles from Rideau lake, on the line of the Rideau canal connecting Kingston and Ottawa, and are owned by Messrs. Cross & Foster of Smith's Falls. Formerly extensive mining had been done on these lots, aggregating 2,000 tons of 80 to 85 per cent. phosphates, which have been sent to the market, with about 250 tons now on hand at the mines ready for sale. In addition, about 100 tons of amber mica have been taken out and sold. Mining has been suspended for the last nine months of the year on account of the dull state of the phosphate market. The mineral extends over a large area on the lots, and the work, which is done by contract, has been confined chiefly to surface openings at depths of from 10 to 15 feet. As no machinery

The Otter mines.

Character of the workings.

has been used in lifting the ore or waste rock to the surface, a large amount of refuse has been left in the cuttings, and as a result, for convenience and ease these cuttings have been abandoned and new ones opened where the ore could more easily be obtained. The mineral occurs in true fissure veins, in more or less regular deposits in the veins, which are nearly vertical, and carry about one-half mineral and the remainder waste. With suitable appliances for lifting the material from the cuttings these veins may be worked to much greater depths, as there is no apparent failure of the mineral.

Rock formation.

The prevailing rocks are pyroxene, micaceous and garnetiferous gneiss, with some bands of crystalline limestones, being those in which the phosphate of lime or apatite is usually known to occur. The greater part of the rocks are covered with a thin deposit of boulders and clay. The veins vary in width from 12 feet down to a few inches.

Mica and phosphate.

On lot 9 there is a vein 10 feet wide of mica and phosphate, some of the deposits being nearly all mica, and others nearly all phosphate. Crystals of mica are obtained from 18 inches down. At some of the places where the mica is exposed it is twisted and broken so that only from 15 to 20 per cent. would be suitable for electrical purposes.

Mr. R. Brodie of Smith's Falls, through whose courtesy I have obtained the description of the Otter properties, states: "As far as I know none of the phosphate mines in the Burgess and Perth districts are being worked this winter. There is something being done at mica. I am informed that Mr. Waters of Ottawa has bought lot 13 in the sixth range of North Burgess, a mica property, and he has a gang of men at work putting in a boiler and engine and some pumping and hoisting machinery, and also laying in a supply of wood."

The superphosphate works at Smith's Falls

Mr. Brodie, manager of the Smith's Falls superphosphate works, writes me regarding them as follows: "We fitted up our sulphuric acid plant with pyrites burners the past year. We still keep the sulphur burners so that we can use either pyrites or brimstone. We have also made some additions in our buildings and machinery, and are now well equipped for grinding and manufacturing phosphates and fertilizers. Our business increases every year."

GYPSUM.

The Merritt mine.

For two months during midsummer the Merritt mine (inadvertently designated the Glenny mine in my last report) was lying idle, but at the date of my visit in December 13 men were employed in the mine and at the mill. The mill had been operated for most of the year, treating about 5 tons of calcine or 12 tons for fertilizing uses in 10 hours. It had been shut down for a couple of weeks, undergoing repairs. The workings in the mine were chiefly carried on in the old openings, and in the usual way of mining the gyysum along the tramway, filling in the open space with the waste rock and moving the tramway again up to the breast of the gypsum. The ore is removed from the mine in the same way as described in the former report.

Output of gypsum.

About 1,200 tons were taken out during the year; 200 tons have been taken to Port Colborne to be used in smelting nickel ore, but the result has not yet been determined. About 300 tons of ore were on hand in the rock house. This mine is not troubled by the inflow of water from the Grand river, the principal workings being in dry rock. Some of the timbers in the old drifts have become defective by decay, leaving parts of the mine in an unsafe condition.

State of the mine.

Mr. Glenny, who still has the charge of the mine, stated that the whole of the work would be properly renovated at the first of the year, and any portion of the timbers which were defective would be replaced by firm new supports. I directed however that on one of the drifts the repairs should be done at once, and that work should be suspended until the drift was put in a safe condition. The mining is still done by contract.

But limited work has been done on the Teasdale property during the year. The drift has been run in 100 yards, and a large body of gypsum opened, but the inflow of water from the river has entirely suspended operations. A wind-mill has been put up over the drift and near the end to drive a pump, but so far it has not proved effective. A small shipment of plaster had been made recently to the Alabastine Company at Paris. There may be at an early date suitable machinery provided for keeping the mine free from water, and for working the large body of ore. In December when in the mine I found the drift neatly and substantially timbered. The work was under charge of Mr. Walton. Teasdale mine.

The Glenny mine, which was designated the Merritt mine in the last report, has not been worked during the year. Idle mines.

The Mount Healey mine is still idle, as are also the Excelsior mine and mill.

An average force of six men has been working during the year in the Martindale mine, but only two men were employed in October when I inspected it. The workings were in a greatly improved condition, and considered safe at the place of working. Very extensive openings have been made in the older workings, which are not now used, and as the work advances the walls are made secure. About 500 tons of plaster have been taken out during the year. The mining is done by contract at 75 cents per ton. The mill of 10 tons daily capacity is running part of the time, grinding plaster for fertilizing purposes. Martindale mine.

At the date of my visit to the Garland mine in December three men were employed, including Captain Wm. Smith, who has charge of the work. The force of workmen would be increased after the holidays. About 9 or 10 tons of plaster were mined and hauled out to the mouth of the drift daily The drifting had been continued to the full distance of 152 yards, and the principal place of working was near the extremity of the drift. As the ore is removed the tramway is moved nearer to the workings and the open space walled in with waste rock The interior of the mine was in a good state of repair. The defective timbers have been replaced by new supports. A shaft has also been opened near the present workings, a depth of 52 feet from the surface, which is used for going into and coming out of the mine, as well as for ventilation, which is good in the mine. I advised that a suitable space or man-hole for refuge be made in the long tramway for safety. The Garland mine. Improving its condition.

The ore taken from the mine is still hauled to Caledonia and ground as a fertilizer in the mill of Messrs. Hull & Olds. Several car loads of gypsum have been sold during the year, to be used in stables as a disinfectant and absorbent. The property has again passed into the possession of Mr. Nicholas Garland of Toronto, the original owner, and whose name the mine bears.

On the 22nd of December I was at the Paris mine property, and found two men engaged in running in a new drift at a distance of 100 feet west of the old one. It had been extended about 100 feet and would reach the bed of ore at the further distance of from 50 to 75 feet. This new drift was being made through the old waste rock left in the earlier working of the mine, and was being substantially timbered and of sufficient height to work a horse or mule in hauling out the ore. This drift would be completed in about a month's time, when the work of taking out gypsum would begin. The quantity of ore taken out of the mine in the early part of the year reached 650 tons, which was ground in the company's mill at Paris for farm use. It is claimed by some that the gray is of more value as a fertilizer than the pure white plaster. The mill is chiefly supplied with ore for alabastine from the beds of white gypsum below Cayuga. Seventy-five tons however were brought from Grand Rapids, Mich., to meet the demand for Paris mine and works. Land plaster. Manufact re of alabas the year. At the time of my visit about three tons were being manufactured into alabastine daily, with a force of 10 or 12 men employed in this department of the company's work. The mill has been refitted and now has a much increased capacity, and is in a good condition every way to turn out an excellent article. This is the only mill engaged in the manufacture of alabastine in the Dominion, and the third one in the world, the other two being, one at Grand Rapids, Mich., and the other in London, England. Mr. B. M. Church of Grand Rapids, who has devoted a great deal of time in perfecting the manufacture of alabastine, is president of this company. He also is the largest stockholder and managing director of the Grand Rapids Company, and he owns a half interest in the company in England. Mr. T. W. Wheeler has still the charge of the company's works at Paris, and he controls the entire operations in Canada. The demand for alabastine is rapidly increasing, as its value becomes known as a pure and wholesome article for the beautiful and substantial decoration of walls and ceilings in dwelling houses.

I was told by Mr. Wheeler that shipments during the year had been made to almost every part of the Dominion, and that a very much larger supply would be required to fill the orders for the coming year.

MINING ACCIDENTS.

Two mining accidents occurred during the year, both of which were at nickel mines in the Sudbury district.

Accident at the Evans mine.

The first of these took place at the Evans mine on the 26th of April, which resulted in serious injury to Andrew Sorin, an employe of the Canadian Copper Company. According to the statements of two fellow-workmen he was engaged as a machine helper in sending machinery down the shaft, being at the time on the fourth level, and having heedlessly stepped out into the shaft the cage came down upon him. It was found that he was badly injured in the spine, and upon the advice of his medical attendant he was sent to the hospital at Toronto for treatment. According to the statements of the men at work with him every necessary precaution was taken to prevent accident, and the usual necessary signals were given before the cage was lowered.

Serious accident at the Blezard mine.

The second accident took place at the Blezard mine of the Dominion Mineral Company on the 6th of September, and resulted in the death of five employes of the Company and the injury of two others, one slightly. The particulars of this accident are given in a special Report made to the Commissioner of Crown Lands, under the provisions of section 65 of The Mines Act 1892.

A. SLAGHT,
Inspector.

Waterford, February 22, 1893.

SPECIAL REPORT ON THE ACCIDENT AT THE BLEZARD MINE.

To the Honorable the Commissioner of Crown Lands:

Special report to the Commissioner.

Sir,—I have the honor to submit to you, in pursuance of your instructions, a special report of the accident in the Dominion Mineral Company's Blezard mine near Sudbury on Tuesday afternoon, the 6th inst., which resulted in the death of five men, crushed beneath a mass of falling rock, and the injury of two others, one seriously but not fatally, and the other slightly. The names of those who were killed are:

List of the killed and wounded.

Duncan A. McDonald, an old miner, who leaves a wife and family;

John Johanson, a Finlander, who had been in the country only a few weeks, and who leaves a wife and two children;

Thomas Faulkner, who leaves a young wife to whom he had been married but two weeks;

A. Picard, single, a French Canadian, who had worked in the section of Sudbury for some years; and

Robert McKinley, single, aged 20 years, whose relatives reside in Ireland.

Damase Cadieux was seriously injured, but not fatally. He has a family. John Brothers was slightly hurt.

The first intimation I had of the sad occurence was on receipt of a telegram from Mr. Blue, Director of the Bureau of Mines, on Thursday, 8th inst., about noon, which was as follows:

"Accident in which five men were killed and two injured at Blezard mine. Better go up at once and investigate under provisions of section sixty-five, Mines Act. Procure plan of work where accident occurred. Answer."

The following reply was sent on same date to the Director:

"Will reach Toronto about ten to-night. Please meet me at station. Shall leave next train for Sudbury."

In our short interview in Toronto the Director informed me that you were absent from the city, and that he had been unable to reach you yet by telegram, but that he would communicate to me at Sudbury any instructions you might wish to give. On my arrival at Sudbury late on Friday, I went immediately to the coroner's office and carefully examined the evidence taken at the inquest, which had been held on Wednesday, the day after the accident.

I arranged with the coroner to procure a copy of the evidence for me, which I sent to the Director for you on the Sabbath following, being the first mail after I obtained it.

Visit to the scene of the accident.

On Saturday after my arrival at Sudbury I went out to the mine and met Mr. Ian Cameron, the general manager of the company, and Robert McBride, the captain of the mine, and they accompanied me to the place of the accident in the mine. I found nothing changed in the mine after the accident, otherwise than what was necessary in removing the bodies of the unfortunate men who had been killed. A considerable part of the day was spent in examining the location of the accident and taking necessary measurements with a view to procuring a diagram or plan of the same.

After my return to town late on Saturday the following telegram came to hand from the Director:

"Procure and send down by first mail copy of evidence taken at inquest. Commissioner directs you to take all necessary and proper measures and make special report."

Immediately I wired answer to the Director as follows:

"Visited mine to-day. Utmost facilities given to investigate. Case serious, and perhaps more satisfactory if you come up and act with me. Will forward next mail copy of all proceedings at inquest. Answer."

The answer of same date received the following day reads:

"Will await evidence and may go up Monday night."

On Monday morning I went out to the mine again and spent noon in further examining the place of accident and completing ments, which, with the aid of the tracings of the mine kept in t enabled me to obtain the plans accompanying this report. Before le mine I decided to return on Wednesday morning following and necessary evidence respecting the condition of that part of the m the accident occurred. This date was fixed to give time for the a the Director should he decide to come up. Monday afternoon was the Murray mine and on my return to town late in the evening th ing message came from the Director:

"I expect to leave for Sudbury to night."

Tuesday I was at Copper Cliff, but spent most of the day at t mine.

Mr. Blue arrived at Sudbury late on Tuesday and on Wednesd ing we drove over to the Blezard mine and were occupied the wh examining the place of accident, confirming measurements and inspecting the present condition of the mine, and in taking evi parties regarding the condition of the place when the accident occu

Those whose evidence was taken on the first day are the follow

Ian Cameron, general manager of the works; Robert McBride of the mine; Alexander Wilson, foreman; Moses Austin, und foreman, and Michael Giroux, laborer; all employed in the servi Dominion Mineral Company.

Late on Wednesday evening the Director and myself returned bury, and as he could not go with me to the mine on Thursday I alone and took the evidence of the following parties, viz: Fra laborer; Peter Wilson, miner; and Thomas James McFarlen, labo

The whole of the evidence taken is submitted herewith.

Summary of evidence taken at the investigation.

I carefully looked over all the discharge papers in the office fo six months, 121 in number, and I found 14 of the number re leaving on account of dissatisfaction. Thirteen of these men were on above ground work. Wages was in most cases of the fourte as the cause of dissatisfaction.

I also obtained the statement of the manager of the compan ing the professional relation of the coroner who conducted the i the company, which is herewith given.

The first plan submitted will show the position of the first lev mine before any part of the rock roof was removed.

In my report of 1890 this part of the mine is described a page 13: "Shafts 1, 2 and 3 are sunk to the depth of 69 fe first level, from which there has been taken 50,000 tons of ore. A of stopes have left the opening or excavation in an irregular fo 150 by 175 feet at the bottom, and extending upwards to within feet of the surface. The rock roof is well supported by four large ore, No. 1, 22 by 22, No. 2, 24 by 16, No. 3, 18 by 24, and No. 24." The extreme distances were taken.

I also referred to this part of the mine in the report of 189 lows: "The rock roof over the extensive excavation referred t former report has been partially removed, showing a thickness var 18 to 27 feet, and a good view of the interior workings can no from the surface, which tends to confirm the previous descri proves the safety of the work at the date of my former report."

The second tracings show the present state of this part of the the extent of roof still remaining. The tracing of the place of shows its state as nearly as could be obtained before the rock

floor of the excavation to the surface is 70 feet, with a
f 11 feet from being perpendicular. From the floor to the
e projecting rock which fell is 18 feet. The length of rock
feet, and from the upper part 33 feet to surface. It
the pillar in width of say 10 feet and the extreme projec-
feet, which would be about the middle of the projection
.

General conclusions.

ormation which I have been able to obtain I am inclined
ordinary care was taken in looking after the safety of the
e certain that the projecting rock which afterwards fell
rmly attached to the wall by the parties whose special
xamine it. Foreman Alexander Wilson, a man of several
in mining, was present at the blasting down of the mantel
g part of pillar No. 1 on Sunday previous to the acci-
ooking at it carefully himself he took the precaution to
Duncan McDonald, an old miner, to inspect it also.
onsidered a man of good judgment, was often consulted
the mine, was entrusted with the charge of a gang of
id extra wages because of his superior experience as a
ounced it safe by saying they had made a good job of it.
ork within a few hours afterwards directly beneath the
and was there until midnight Sunday, and also worked
esday. Frank Blum, who worked with him that night,
nce that "there was no conversation between McDonald
o there being any danger, and I did not notice anything
eman Wilson often passed underneath the projecting
here but a few moments before it fell. The projection
d place to the light, the roof above having been removed
nce around, which gave the best possible opportunity to
slip, or fault of any kind. If it had been under cover,
could have been seen, then it should have been tested
t and examining it with hammer, pick or gad, or other-
where the accident occurred was in the open daylight,
evidence obtained no one of the mining men who were
spoke of it as a place of danger. The general manager
Mr. Cameron, in company with Mr. McBride, the captain
nt some time in the open workings of the mine and in
projecting work but a short time before the accident;
for the special purpose of looking over every part of the
e discussing plans for future operations in the mine.
gard the place as dangerous, and indeed were congratula-
upon the safe appearance of the mine.

ce taken it was shown that when any projecting rock had
f danger a man was lowered from the surface to test or
This had been done repeatedly.

l of the rock it could be seen that a seam or defect
, but it is by no means certain that it could have been
. The presumption is that it could not have been seen,
ct was inherent.

I have the honor to be, Sir,
Your obedient servant,
A. SLAGHT,
Inspector.

mber 22, 1892.

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onor GEORGE AIREY KIRKPATRICK,

Lieutenant-Governor of Ontario :

the honor to transmit herewith, for presentation to the Legislative the Third Report of the Bureau of Mines.

I have the honor to be, Sir,

Your obedient servant,

A. S. HARDY,
Commissioner of Crown Lands.

OF CROWN LANDS,
, April 27, 1894.

nes)

THIRD REPORT OF

THE BUREAU OF MINES.

To the Honorable **Arthur S. Hardy**,
Commissioner of Crown Lands:

Sir,—I have the honor to submit herewith, for presentation to His Honor the Lieutenant-Governor, the Third Report of the Bureau of Mines.

Scope of the Report.

Besides the statistics of mineral production in the Province, and of mining lands leased or sold by the Department of Crown Lands last year, this Report deals with several subjects which are attracting notice at the present time.

Gold fields of the Province.

One of these subjects relates to our gold fields. Last year I visited mines in the Lake of the Woods region, in the district north of Lake Huron and Georgian Bay, and in the county of Hastings, and a full account of operations in those several fields is given in the Report. I also performed the duty of inspecting the several gold mines and mills, and therefore it was not necessary for the Inspector to visit them. The prospect of gold mining in the Province has greatly improved during the year, and with new fields to attract the industrious explorer there is promise of increased activity this year.

Copper-bearing formations at Point Mamainse.

Another portion of the Report is devoted to an account of exploratory work undertaken at Point Mamainse, on the east shore of Lake Superior, with the object of ascertaining the value of the copper-bearing formations there, which are identical with the copper-bearing rocks in Michigan, on the southern shore of the same lake.

Fibrous talc and actinolite.

Our deposits of fibrous talc and actinolite in the counties of Hastings and Addington have also received attention. The talc industry has recently been largely developed in the State of New York, where the value of the yearly output of the mills has reached half a million dollars. With properly directed enterprise there is, I believe, a good field for mining and milling talc and actinolite in this Province also.

Vitrified brick for street paving use.

The adoption of vitrified brick as material for street pavement has been made the subject of enquiry by the Secretary of the Bureau, Mr. Gibson. There is no doubt as to the suitability of brick for this purpose, as is amply shown by the experience of American cities; and if, as is almost certain, we have clays for the manufacture of vitrified brick of the right quality—such as our beds of Hudson River and Medina shales—a new industry of no little importance may soon be established in the country. The yearly demand for pavement material in our towns and cities is large and steadily growing; and if we can employ labor and capital to produce a good article at home, it is much better that we should do so than continue dependent on foreign supplies.

Utilization of peat.

The utilization of peat is a subject that continues to receive attention, and inventors of various processes of treatment for the production of fuel are sanguine of ultimate success. For a paper on other uses of peat I am indebted to Mr. Edward Jack, of Fredericton, New Brunswick.

Report of the Inspector of Mines.

The annual report of the Inspector of Mines accompanies the Report of the Bureau.

I have the honor to be, Sir,

Your obedient servant,

ARCHIBALD BLUE,

Director.

Office of the
BUREAU OF MINES,
Toronto, April 27, 1894.

REPORT OF

THE BUREAU OF MINES.

I.

STATISTICS.

much change to note in the condition of the mining industry ics of last year's production are compared with those of the There has been a decrease in the quantities and values of nd nickel and copper, but this is offset by the increase in the alues of petroleum products. Transactions in mining lands, noticeable increase in the number of locations leased or sold, a lowering of average areas. The activity displayed in the he year was not maintained in the latter part ; but inasmuch ortion of those who take up mineral lands in Ontario are falling off was no doubt a consequence of the financial dis- overtook them at home.

Comparison with the previous year's statistics.

SALE AND LEASE OF MINING LANDS.

g table gives the number of patents for mining lands issued h of the several districts, the areas of the locations, and the he sales realized :

Statistics of locations sold

District.	No. of patents.	Acres.	$
iny River	41	2,390.72	6,856 00
under Bay	4	362 50	920 75
goma	3	410.00	1,113 00
pissing	3	200 00	622 00
ewhere	12	1,007.00	1,986 25
Totals	63	4,370.22	11,498 00

the above are two patents of mining rights, sold under the ction 19 of The Mines Act 1892. They embrace an area of he price paid was $232.50.

The number of patents issued in 1892 was 65, covering 6,200 the price paid was $15,273. There was only a difference of two i ber of patents issued in the two years; but while in the former t area was 95.38 acres, it was in the latter only 69.37 acres.

and of locations leased.

The next table gives the number of mining leases issued in ea the area covered by them, and the amount received for rent of the

District.	No. of leases.	Acres.	$
Rainy River............	68	6,857.00	6,857 00
Thunder Bay	3	360 00	260 00
Algoma	32	3,540.62	3,458 88
Nipissing..........	7	599.63	536 62
Elsewhere	12	1,689.50	821 40
Totals.......	122	13,046.75	11,933 90

Included in the foregoing are 11 leases of mining rights, gra the provisions of section 19, embracing an area of 1,094½ acres, for first year's rent was $401.05.

In 1892 the number of leases issued for mining locations was 9 13,122½ acres, and the amount of first year's rent paid was $12,3 average area of locations being 138.13 acres as against 106.94 acr

The amount of rentals received in 1893 on leases issued in 189 was $2,735.86, as against $603 received in 1892 on leases issued in 1 total amount of receipts for sales and rentals last year was $26,1 in the previous year $28,190.36.

MINERAL STATISTICS.

Building stone.

The value of the product of 310 stone quarries last year is co $721,000, made up as follows: 1,400,000 cubic feet dimension s 000; 44,700 cubic feet heads and sills, $21,000; 170,000 square y ing stone, $180,000; and 410,000 cubic yards rubble stone, $260 number of workmen employed at the quarries was 1,700, and the for labor $464,000.

Cements.

The manufacture of cements is steadily increasing. There ar works producing Portland and five producing natural rock ceme year the output of Portland cement was 31,924 barrels, valued a and of natural rock cement 74,353 barrels, valued at $63,567. T of workmen employed in the industry is 224, and the amount of for labor $60,208. Tests of Portland cements used in Toronto some of the brands manufactured in Ontario are superior to th cements of the same class.

Lime.

The number of lime kilns in operation in the Province is abou last year they produced 2,700,000 bushels valued at $364,000. T of workmen employed at the quarries and kilns was 600, and t paid for wages $122,500.

There are in the Province about 350 works for the manufacture of common brick, of which about 150 are also employed in the production of drain tile. The output of these works last year was 162,350,000 brick, valued at $932,500, and 17,300,000 drain tile, valued at $190,000. The number of workmen employed in the joint industries was 2,650, and the amount paid for wages $451,000. Brick and tile.

Six works were employed in the manufacture of pressed brick and terra cotta, the output of which was 20,208,000 plain brick, 1,373,000 fancy brick and 53,000 of roofing tile. The aggregate value of brick, roofing tile and terra cotta products was $217,373. The number of workmen employed was 224, and the amount paid for wages $80,686. Pressed brick and terra cotta.

Two companies have been carrying on the manufacture of sewer pipe, one of which was started last year and worked only part time. The average number of men employed was 85, and the amount of wages paid $34,000. The value of product was $230,000. Sewer pipe.

There are about forty works in the Province employed in the production of pottery. Last year the total value of wares made was $115,000, employing the labor of 150 men, whose wage-earnings reached $36,000. Pottery.

The gypsum industry is making slow progress, and last year only four of the six companies which own mines and works on the Grand river were actively employed. The total quantity of gypsum mined is reported to be 2,958 tons, the greater portion of which was ground into land plaster. The value of raw gypsum and plaster (2,818 tons) is computed to be $7,363. The rest of the mineral, 140 tons, was manufactured into alabastine and plastico at the new works at Paris, and is valued at $14,800. The number of men employed at the mines and works was 33, and the amount of wages paid $9,220. At the alabastine works gypsum is now being used in the manufacture of a potato bug poison, which is claimed to possess the double merit of destroying the bugs and fertilizing the crop. Gypsum and alabastine.

The apatite or phosphate of lime mines of the Province were idle last year, with a single exception ; the cheaper production of South Carolina and Florida mines continuing to make operations in Ontario unprofitable at the European prices. One mine was worked for a short time by four men, who raised 20 tons valued at $200. The cost of labor was $500. Phosphate of lime.

The salt-making industry remains practically at a standstill, for although the production was greater last year than in the preceding year, the aggregate value was less. The new Canadian Pacific Railway works at Windsor did not begin operations until late in the year, and two other works in Huron were idle. The total output of fifteen establishments was 39,150 tons of fine and 9,300 tons coarse salt, the value of the former being $123,450, and of the latter $26,400. The number of workmen employed was 210, and the amount of wages paid for labor, $44,440. In 1892 the total product was 43,387 tons, valued at $162,700, and the wages paid for labor $37,800. Salt.

Mica.

Mica mining was limited to operations on five properties, wher
were produced, valued at $8,600. Forty workmen were employed
amount of wages paid was $4,500.

Nickel, copper and cobalt.

With the exception of operations at Point Mamainse on Lake S
open up the copper veins there, all mining for copper and nickel i
vince during the year was carried on in the Sudbury district. Five
were employed in the industry, but owing to financial difficulties c
works was closed for the greater part of the year. The total quant
raised was 64,043 tons, and the quantity smelted was 63,944 t
product of the furnaces was 7,176 tons of ordinary and 452 tons of
ized matte, the metal contents of which are estimated to be 1,431 to
1,642 tons nickel and 19 tons cobalt. Values are computed on tl
price of matte at the furnaces, and are for copper, $115,200;
$454,702; and for cobalt, $9,400, being a total of $579,302. Th
number of workmen employed at the mines and works was 495, co
129 men underground and 356 men and 10 boys under 17 ye
ground, and the aggregate of wages paid for labor was $252,516
running time of the smelting furnaces in the year ranged from 46 to
and the working time in the mines from 40 to 297 days in th
aggregate working time of men under ground being 24,348 days.

A Duluth company began late in the year to open up a prom
perty on lots 10 and 11 in the third concession of Trill, where a
been sunk on a body of solid ore. It is the intention of this compa
exploration work is satisfactory, to erect a plant for treating the
new process, from which good results are expected.

Gold.

Fifteen gold properties were worked during the year, upon wl
was expended to the amount of $49,027. The average numbe
employed above ground on all the properties was 112, and below g
The work however was chiefly of a development character, the cost
bears no relation to the gold product. Nine mills for treating ore
operation, but none of them for a long period. Four of these were
mills, four were stamp mills, running a total of fifty stamps, and c
for treating refractory ores. The latter was an experimental plant,
test a new process of extracting gold from mispickel, and its capacit
five tons per day. Two of the stamp mills were completed only a
before the close of the year, another was closed down for repairs f
months, and the fourth was idle for nearly the whole of the year.
ford mills do not appear to have given much satisfaction where
tried, and none of them were run for more than a few days.
quantity of ore treated during the year was 5,560 tons, which yie
ounces of bullion, valued at $32,960.

Silver.

Silver mining was inactive throughout the year. All the produ
were shut down in consequence of the depreciation of silver, and
work done was of a development character. Five men were em
sixty days at a cost for wages of $400. The quantity of ore pro
500 tons, with a nominal value of $2,500.

Petroleum.

The shipments of crude and refined petroleum from the Petrolea and Oil prings fields for the year ending 31st October was 1,045,000 barrels, eckoned in the equivalent of crude ; but the produce of the year was 72,000 arrels less. The yield of the Petrolea field was 795,131 barrels, and of the il Springs field 177,869 barrels, or 34,055,000 imperial gallons, valued in the rude at $1,099,868. Returns from the refineries are only complete for 1,160,170 gallons; but with the data which these afford it is possible to ake a very close estimate of the production of all the refineries. The verage of illuminating oil in the crude was 39.12 per cent., at which rate the otal of the distilled oil would be 13,322,320 gallons, valued at $1,372,209. he yield of lubricating oils was 12.45 per cent. of the crude, giving a total f 4,239,847 gallons, valued at $277,500. All other products except paraffin ade up 28.14 per cent. of the crude, or a total of 11,220,705 gallons, valued t $323.156. The paraffin wax product is computed to be 2,250,000 lb., alued at $143,325. Besides the above, a produce of the crude was utilized r fuel, the value of which is computed to be $72,500. The aggregate value f the industry was therefore $2,188,690, and it gave employment in the efineries to 515 men, whose wage earnings are computed at $302,000. The umber of men employed in other departments has not been ascertained, but e total number employed by the industry is not less than 1,500.

Natural gas.

Seventeen firms and companies have made returns of natural gas produc-on, but six of these were inoperative for the whole or a greater part of the ear. The number of wells bored during the year was 27, of which 19 were roducers and 8 non-producers. The whole number of producing wells in the rovince was 107, and the total yield of gas is computed to be 2,342,000,000 ubic feet, valued at $238,200. Eight wells in the Essex field have an timated daily capacity of 42,000,000 cubic feet. Hitherto these wells have een supplying the villages of Kingsville, Ruthven and Leamington, but an ght-inch pipe line is now being laid to supply Sandwich, Windsor and alkerville, about 35 miles distant from the wells. Last year there were 17 miles of pipe lines in the Province ; the number of working men employed the industry was 59, and the amount paid for wages, including the cost of bor drilling wells, was $24,592.

Fibrous talc and lithographic stone.

Mining operations were carried on in the county of Hastings, opening up rous talc properties in the township of Elzevir, and lithographic properties Marmora ; but although they gave employment to a considerable number men, at a cost of several thousand dollars in wages, the work was mainly a development character, and mineral was not produced in marketable antity. The results of these operations accordingly cannot be presented in atistical form, but hopes are entertained that the properties are in a position produce considerable quantities both of fibrous talc and lithographic stone ring the present year.

SUMMARY OF MINERAL PRODUCTION.

Quantity and value of mineral production in 1893, with number of workmen employed and amount of wages paid for labor.

Product.	Quantity.	Value.	Employés No.	Wages.
		$		$
Dimension stone, cubic feet......	1,400,000	260,000	1700	464,000
Heads and sills, " "	44,700	21,000		
Coursing stone, square yards....	170,000	180,000		
Rubble, etc., - cubic yards.....	410,000	260,000		
Natural rock cement, barrels.....	74,353	63,567	224	60,208
Portland cement, "	31,924	63,848		
Lime, - - - - bushels.....	2,700,000	264,000	600	122,500
Drain tile, - - - - - No......	17,300,000	190,000	2650	451,000
Common brick, - - - "	162,350,000	932,500		
Pressed brick, plain, - "	20,208,000	217,373	224	80,686
Pressed brick, fancy, "	1,373,000			
Roofing tile, - - - - "	53,000			
Terra cotta, - - - - "				
Sewer pipe, - - - - "		230,000	85	34,000
Pottery, - - - - - "		115,000	150	36,000
Gypsum, - - - - tons......	2,818	7,363	33	9,220
Alabastine and plastico, "	140	14,800		
Phosphate of lime, - - "	20	200	4	500
Salt, - - - - - - - - "	48,450	149,850	210	44,440
Mica, - - - - - - - - "	70	8,600	40	4,500
Nickel, - - - - - - - "	1,642	454,702	495	252,517
Copper, - - - - - - - "	1,431	115,200		
Cobalt, - - - - - - - "	19	9,400		
Gold ore, - - - - - - - "	5,560	32,960	168	49,027
Silver ore, - - - - - - "	500	2,500	5	400
Petroleum, imperial gallons......	34,055,000			
Illuminating oil, " "	13,322,320	1,872,209	515	302,000
Lubricating oil, " "	4,239,847	277,500		
All other oils, " "	11,220,705	323,156		
Paraffin wax, - - - lb......	2,250,000	143,325		
Fuel product		72,500		
Natural gas, M cubic feet	2,342,000	238,200	59	24,592
Totals..........		6,120,753	7,162	1,935,590

II

E GOLD FIELDS OF ONTARIO.

ut a quarter of a century ago in Hastings county, and again ars ago in the Lake of the Woods region, discoveries of gold, aines and milling of ores had encouraged the hope that Ontario a gold producing country. But for one cause or another, after and labor had been expended upon properties and works, the peared to be reached that the right conditions did not exist, or at the energies of those who ventured upon the enterprise were uate or were misguided and misapplied. Past experience how- persuaded the men of our day that there is not gold in our vorkable quantities in districts not hitherto explored, nor even s where operations were formerly carried on without success ds and appliances may not yield profits to those who have the ndertake their development with more capital, modern equip- w modes of treatment. It was remembered perhaps that in the f quartz mining in California and elsewhere, with the old-time reatment, more gold went off with the tailings than was caught nd it was no doubt believed that with the more scientific methods es might be treated with profit which twenty-five or thirty years own into the dump. It come to be known also that gold was Hastings county or the Lake of the Woods district, and confi- lt that in the wide area over which formations which may be extend there is a chance for making valuable discoveries. rospecting for gold in various parts of the Province began there- , new discoveries were reported, and in several localities mining operations started to attract notice. Silver mining had enjoyed of prosperity, and the rich and extensive mines of the western Territories had enabled their owners to amass great fortunes. ices fell below a point at which it was alleged production ceased erative, the millionaires of the West closed their mines and eir employés were left to shift for themselves as best they could. so, it may be said, a touch of politics in the turn of affairs in the s, arising out of the repeal of the Silver Act. Nevertheless it in that country until capital and industry commenced to take properties, to explore and work them; and the same thing Ontario also, after the silver mines of Lake Superior had closed, scoveries of gold were made which seemed to give promise of terprise. Other causes had also influenced the movement towards g of gold fields, the most potent of which doubtless was the

Gold mining in Ontario at earlier periods.

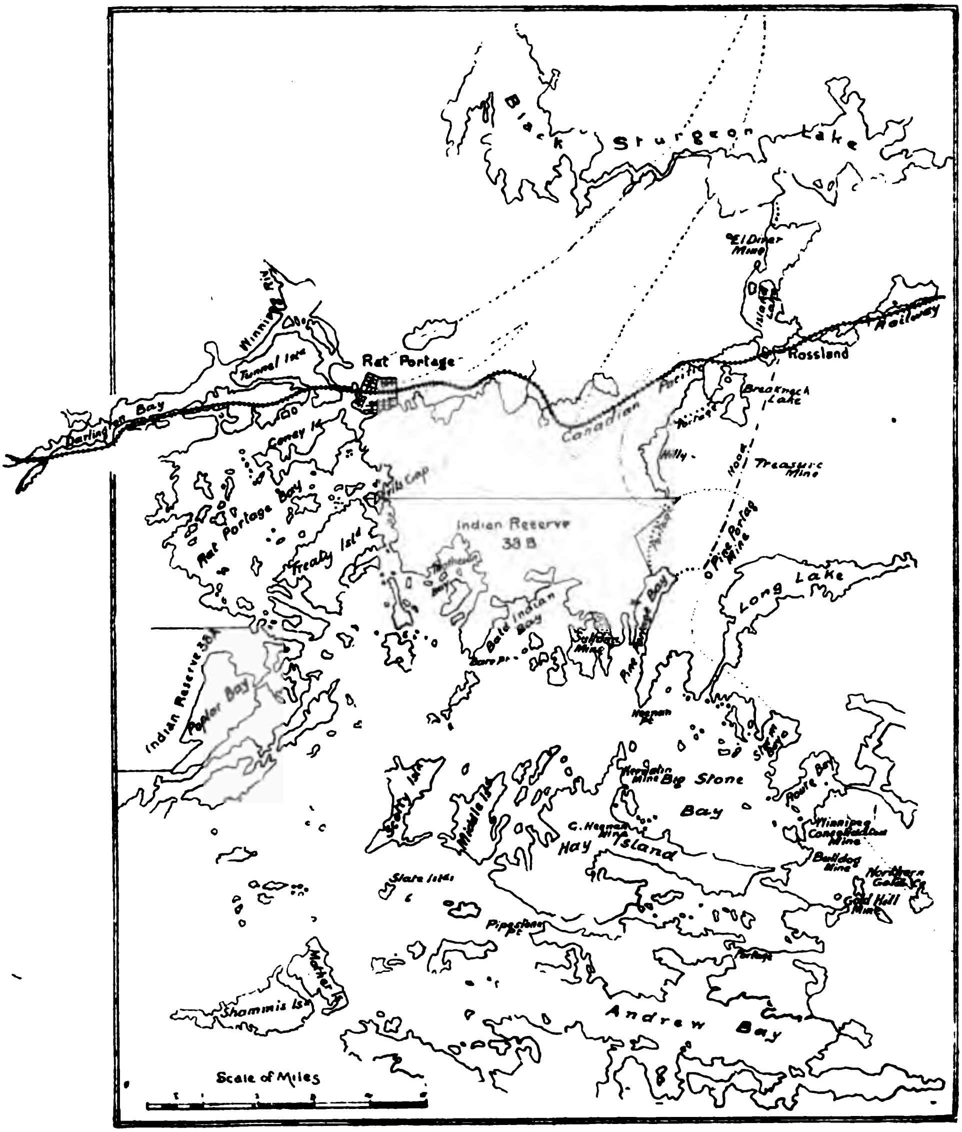
Revival of interest in the industry,

and some causes thereof.

Silver mines closed,

and the iron trade collapsed.

collapse of the iron trade So many iron mines were shut down in the United States, and so many furnaces blown out, that men with capital to spare were ready to take risks in any new venture which had in it the appearance of a healthy speculation. Every business undertaking is more or less uncertain; and while in gold mining there are perhaps more blanks than prizes drawn,



1. Map of northern part of Lake of the Woods. The curved dotted line shows the division between the Huronian and Laurentian formations.

An element of speculation in gold mining,

the blank as a rule deters few and the prize encourages many. We may have too much silver or iron, lumber or wheat; but no one fears that we can have too much gold. Moreover, whilst almost every other article of commerce needs to be pushed upon the market, requiring the service of an arm of commercial agents and middlemen, no trouble is ever experienced in disposing of gold; it has only to be deposited in the bank or expressed to the mint, and forthwith there is an end to the anxieties of the producer. Other occupations may afford larger profits, but there are none in which there is less uncertainty in making sales, and none in which the fluctuations of prices are maintained within narrower margins. And so the industry of gold mining will often attract capital and labor when all other industries are in a state of paralysis. It can only be carried on at a loss when the cost of producing a dollar's worth of gold is more than a dollar. Whether it will be profitable in Ontario or not at this third effort to establish it, remains to be proven.

but sureness of a market for the product.

The renewed interest in prospecting in various localities, the discoveries reported, and the commencement of mining and milling operations on several new tracts, as well as resumption of work after a period of inactivity on the two old ones, suggested the propriety of devoting special attention to our gold fields during the past summer, the results of which are presented below. Two new fields have since come into notice, each of which may possibly prove to be of greater value than any of the ones referred to here. On Rainy Lake gold was discovered upon the American side of the international boundary in the month of August last year, and since then numerous gold-bearing veins have been explored on the Ontario side of the lake and on the Seine and Manitou rivers, the shows of which are so good as to have attracted to the region large numbers of prospectors. Around Lake Wahnapitae in the eastern part of the Province gold was discovered several years ago, but it is only very recently that ore of much promise has been found there. If the samples shown are any indication of the general character of the ore, the Wahnapitae country also will merit and reward the attention of the gold-seekers.

Our gold fields.

In the description of ores and rocks of mining properties in this section of the Report I have in all cases consulted Dr. Coleman, who has this year been appointed Geologist and Mineralogist of the Bureau.

THE SULTANA ISLAND MINES.

Sultana island is on the north shore of Lake of the Woods. In a direct line it is four and one-half miles southeast of Rat Portage; but the overland route is used only in winter, and even then it is hardly better than a snowshoer's trail. By water the distance is eight miles,—southward through the Narrows between the mainland and Coney island in Rat Portage bay, and the Devil's gap between the mainland and Treaty island on the south side of the bay; southeastward by groups of small islands to Bare point, a long tongue of land separating Matheson and Bald Indian bays; and eastward over a stretch of open water and through another group of green islands to the brown and naked Sultana. This is the summer route, and in good weather it may be taken safely and pleasantly in a canoe. But gusts of wind spring up often without warning on Lake of the Woods, and the canoe is then a frail craft in the lumpy waters. Tugboats are not too safe at such times, especially beyond Bare point, where the wind has a long sweep. But usually it is a delightful trip from Rat Portage to Sultana island, for there are many fine

Sultana island, in Lake of the Woods.

bits of scenery. Perhaps none are more picturesque on this beautiful lake than the little bay with darkly wooded shores above Devil's gap, and the narrow gap itself through which the waters of the lake rush swiftly out into Rat Portage bay.

OPHIR MINE LOCATION.

Originally attached to the mainland.

In a survey and map of Indian Reserve 38B made for the Dominion Government in 1880 what is now known as Sultana island was shown to be part of the mainland, but separated from it by a swamp or marsh. It was included with the Reserve, yet the timber upon it was claimed under the Mather lease (which covered the islands in Lake of the Woods), and in 1880-1 most of the pine on it was cut by the Keewaydin Lumber Company. Six or seven years afterwards, when a dam was built across the middle outlet at Tunnel island, the level of the lake was raised about four feet, and then, if not before, Sultana became an undoubted island. About that time also gold was discovered on the western side of the island, across the channel from the quarry on Quarry island, from which stone was taken for bridge piers on the Canadian Pacific Railway. An intrusive mass of granitic or gneissic rock rises here through the hornblende schists of the district and occupies nearly the whole of Quarry island and a large part of Sultana.[1] Many veins or stringers of quartz intersect this area of gneiss in irregular courses, some of which were discovered to carry free gold. Previous to 1888 applications had been received by the Ontario Department of Crown Lands for mining locations on Sultana island, but before any patents were issued the Department of Indian Affairs asserted its control on the ground that the land was part of Indian Reserve 38B and at the time of the survey was attached to the mainland. The claim was ultimately allowed by the Local Government; but a right of occupation was maintained for several years afterwards by the Keewatin Lumber Company under the provisions of the Mather timber limit lease, and the titles granted by the Dominion Government were under a cloud. The matter was finally settled in November, 1891, and the patentees were left in undisturbed possession by the Lumber Company. But in the meantime the island was overrun by fire, and scarcely a living tree was left upon it. The brown and naked rocks of the west shore now stand out prominently, and the contrast with the green islands in front is striking.

Quarry island.

First discovery of gold, and issue of patents by the Dominion Government.

Ophir mine location.

The Ophir mine location, opposite Quarry island, is said to be the first on which gold was found, and specimens taken from it created the impression that it was a very rich property. It is held by the Ontario Mining Company, but a wrangle amongst the officers and shareholders has hindered operations upon it. At one time it was bonded to an English syndicate, and it is said that a shaft was sunk on one of the veins to a depth of fifty feet, with excellent showings, but the wrangle of the shareholders broke out afresh and the ore was thrown back into the shaft, which is now filled with water. There is no h ore was found, for although the dump has been picked over and visitors many times, fine specimens showing free gold may

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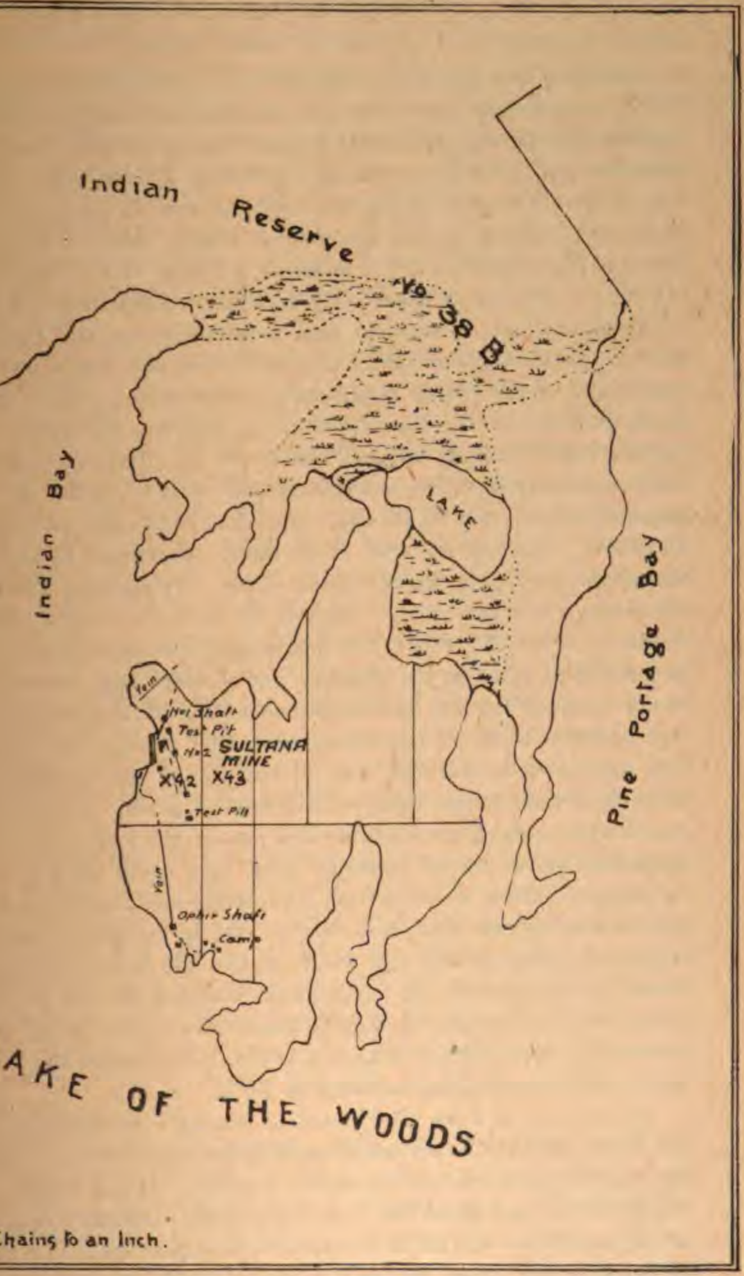
[1] A note on Lawson's map (Geological Survey Report, 1885), referring to this area says: "A boss of coarse grained, gray granitoid gneiss projects through the schists on Quarry island and on the opposite shore. A quarry has been opened in this for material for bridge piers, and the gneiss or 'granite' as it is called, is found to furnish excellent blocks for heavy masonry. Small veins of quartz carrying molybdenite traverse the gneiss in places, and larger veins of molybdenite have been found in the country between Quarry island and Rossland."



Island according to survey of the Department of the Interior in 1880; showing also the plans of mining locations on the island.

e. I found a number last summer. The vein matter is chiefly
ky quartz; some samples are smoky, probably owing to the

presence of hornblende. But what is going to be done with the property, nobody appears to know. The property was patented by the Crown to H. G. McMicken of Winnipeg, 23 July, 1890.

THE SULTANA MINE.

The Sultana mine location.

Sultana mine, known as location 42x, adjoins the Ophir property on the north, and occupies the whole of the northwestern corner of the island. It is indented on the west and north by small bays, between which a low nose of schistose rock extends out to the northwest, covered with a few feet of rich soil. Along the shore of the west bay the rock is gneiss, the same as on a large part of the Ophir location and on Quarry island. It rises inland in a series of steep benches or terraces to a height of 150 feet above the lake, where it is covered by masses of greenstone. The area of this location is only 27 acres, one-half of which is high rocky tableland, and the remainder low and comparatively level land along the north and west shores. The patent was issued by the Indian Department in November, 1888, to H. Bulmer, jr., J. H. Henesy, C. A. Moore, and S. S. Scovil. In April, 1890, John F. Caldwell of Winnipeg became the owner of all except a sixteenth interest held by Henesy, and this was purchased by him in the fall of 1892. He also acquired location 43x on the east, which had been patented to Messrs. Bulmer and Hart; this has an area of 40 acres. Previously he had purchased an interest in the Ophir, which he still holds. Prospecting was commenced on the Sultana location by Mr. Caldwell in 1890, but actual mining was not begun until March, 1892. The prospecting operations proved that there are at least three veins on the property, one of which runs close to the shore line of the west bay through the low ground a little east of north towards the north bay, and that there are two others along the terraces nearly parallel to the first and probably running into or cutting it before reaching the north shore line, their course being a little west of north. There is evidence of a fourth vein crossing the northwestern part of the location in a northeast and southwest course, but no openings have been made upon it. A fifth skirts the northern shore, showing itself by splashes and lines of quartz at frequent intervals on an east and west course, and is probably a continuation of a large and clearly defined vein which crosses the nose of the promontory between the two bays on the north side of locations 42x and 43x, which is about 10 feet wide and covers the sloping bank down below the water's edge. The vein on the upper terrace is known as No. 1, the one on the lower terrace as No. 2, and the one along the shore as No. 3.

Prospecting operations.

Principal veins of the location.

No. 3.

At the base of a low bluff near the southern extremity of the west bay, No. 3 vein crops out very conspicuously, one side of which is along the water line and the other enclosed by a wall of gneiss. It is a whitish yellow quartz, 28½ feet wide, and quite free from any portion of country rock. Sixty yards south, where the vein might be expected to appear again in a steep projection of the shore line, there are only scattered bands or stringers of quartz from one to six inches wide, but extending over a breadth of 30 feet. On a low beach 150 yards northward it reappears from the bluff of gneiss, but enclosed on either side with a selvage of mica-chlorite schist, the total width of the vein between the walls of country rock being about 30 feet. At this place the stamp mill has been erected, and in blasting for the foundations large masses of interbanded schist and quartz were thrown out. The vein has been worked by an open cutting some 75 yards beyond the mill, where it appears again to dip under the gneiss. The total width of quartz and schist ranges from 20 to 25 feet, and it is claimed to be free-milling throughout. About four feet of the middle of the vein is a thorough-going quartzite, samples of which furnish a good illustration of stratified quartz, carrying brown oxide of iron and some iron pyrites. The cutting on this vein north of the mill ranged from 12 to 20 feet in depth by 20 to 25 in width, but owing to its nearness to the lake water flowed in so freely through the joints of the rock that work at this point could not be continued to a greater depth without the use of a strong pump.

In the bluff above the most southerly exposure of No. 3 vein, and about 60 yards east of it, No. 2 vein crops out and a cross cutting has been made upon it there to a depth of 25 feet. The course of the vein at this cutting is irregular, and it is not easily traced; but apparently it continues northward through a gap or ravine east of the bay to rise in one of the terraces behind the mill, where it is well defined. There, about 70 yards from the mill and within 15 yards of the open cutting on No. 3 vein, a shaft 6 by 14 feet was sunk last summer to a depth of 30 feet. The vein was found to dip towards the west at an angle of 75°, in silicious gneiss; but a casing of schist lies between the walls and the quartz varying from half an inch to two inches in thickness. At 15 to 18 feet the vein was found to be irregular, but the walls continued to be clearly defined and the character of the quartz to improve. Samples of the selvage taken from the bottom of the shaft consist of fine-grained lustrous mica-chlorite schist, holding crystals of iron pyrites, and samples of the centre of the vein of a purplish quartz with mica chlorite schist and iron pyrites. No. 2.

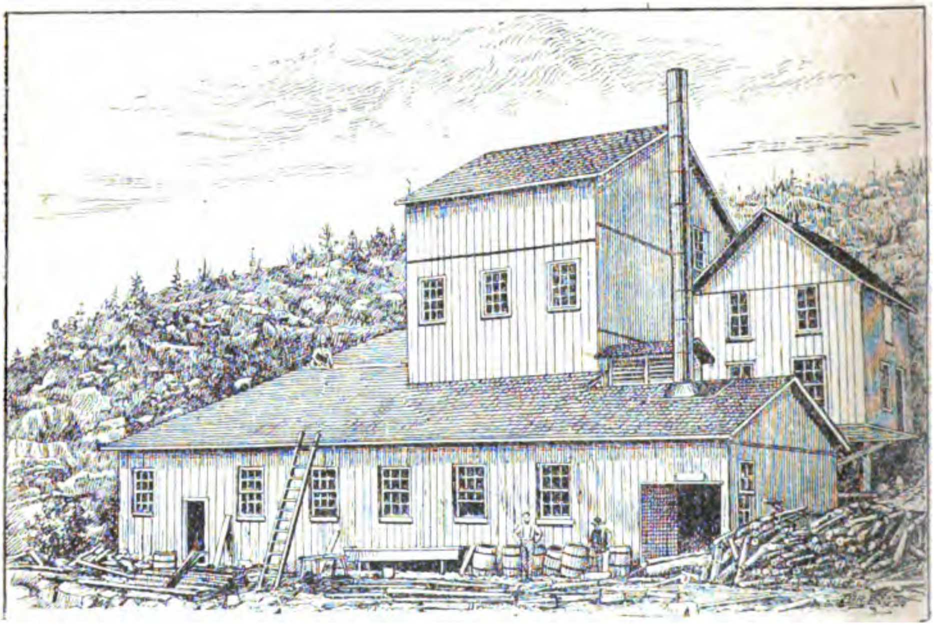
Above No. 2 vein about 50 feet and running in nearly the same course is No. 1 vein, on which a shaft 12 by 7 feet was sunk last summer to a depth of 30 feet. At the surface the quartz matter of the vein is 3 feet wide, with 10 feet of schist on the foot and one inch on the hanging wall, enclosed on both sides with gneiss. The dip of this vein is in the opposite direction from that of No. 2, being about 70° east. Samples of the ore contain pyrrhotite, galena and iron pyrites, the last two predominating, and also some copper pyrites and zincblende. It is claimed that some of the ore from this shaft milled as high as $300 per ton. No. 1.

Those three veins gradually approach each other northward, and at a point about 75 yards from the shaft on No. 2 vein a shaft was sunk through the gneiss to a depth of 25 feet in the hope of striking them. Five feet of the bottom of this shaft shows schist and quartz, but in case this should not prove to be the vein proper it was Mr. Caldwell's intention to explore by cross-cuttings. Later in the season however he decided to sink a deep shaft on No. 3 vein at the northern terminus of the open cutting, and by the end of the year he had reached 100 feet. Twelve miners and two blacksmiths, Sinking a deep shaft on No. 3 vein.

working by night and day shifts, were able to make rapid progress, and the mill was supplied with good pay ore. Operations were arrested for some time by the flooding of the shaft from the lake, but this was overcome by putting in a pump of sufficient capacity, and work has been continued throughout the winter. At this date the shaft, which is 7 by 14 feet, is down nearly 150 feet, and proves the size of the vein to be well maintained, and the ore of good average quality, it being almost wholly free-milling. By driving levels the supply to the mill has been considerably increased, and the mine is now considered to be on a paying basis. Much of the work hitherto has necessarily been of a prospecting and experimental character.

The mill and its equipment.

About 200 tons of ore had been taken out of No. 3 vein, where it outcrops on the western bay, to be tested at the Rat Portage reduction works; but no portion of it was satisfactorily milled, and it remained for Mr. Caldwell himself to prove its value by erecting a stamp mill on the location. The mill was commenced on 26th September, 1892, and finished with its equipment of machinery in December. The site as already stated, is close upon No. 3 vein, on the low open space along the west bay. The main building is 65 feet by 30, raised in terraces against the bluff, with an engine room 20 by 25 feet, and an office building of two and a half stories, 36 feet square. There are two engines, one of 100 h.p., built by the Waterous Engine Works to drive the mill, and one of 8 h.p. built by the Doty Company to run a dynamo. The stamp mill was supplied by the Jenckes Machinery Company of Sherbrooke, but the shoes, dyes, bossheads and tappets are of American manufacture. There are two batteries of five stamps each for reducing the ore, each stamp weighing 850 lb. and running with a drop of six inches at



3. Sultana Gold Mill, on Sultana Island.

r minute.[2] The aggregate stamping power of the batteries is
0 foot pounds per minute, or 275,400 foot tons per day of 24
enormous energy results in crushing only 20 tons of ore to a
ing in water through a 40-mesh sieve (*i.e.*, 1,600 meshes per
hat is to say, a stamping power of 13,770 foot tons is required to
f ore to the condition in which the free gold in it is taken up by
act which vigorously illustrates the cost of gold-winning. The
of the mill consists of a hoisting drum with steel-wire cable to
e mine; a Blake crusher, with a capacity of 40 tons per 24
ch feeders, which feed the ore automatically to the stamps from
wo improved Frue vanners with corrugated rubber belts, over
is run to produce concentrates after it has left the amalga-
and a Blake pump to supply water for the batteries and other
ater being pumped out of the lake to a steel tank at the top
ere is also a cyanide plant, which was added last summer,
ractical value, as nearly all the gold in the ore is saved on the
al cost of the mill and plant is about $30,000.

ill was started on the 20th of December, 1892, but owing to
of the dies and other defects it was run irregularly until
nuary, when new castings were procured from the States.
continued until the end of April, the gold product being
ded through the Imperial Bank agency at Rat Portage to the
ch of the U. S. mint. The mill was closed down during four
ummer, while the plant for the cyanide process was being set
n to run again in September and has been working steadily
e or two short interruptions.

Operation of the stamp mill.

l has met with a full share of the pioneer gold miner's diffi-
as faced them with courage, intelligence and enterprise; and
ty has not yet proved to be a bonanza, there appears to be
the hope that it will yield a liberal return. We have not had
Ontario who have shown such tenacity of purpose as Mr.
one who have shown a better example of what pluck and skill
deserves to succeed.

Pioneer difficulties.

es of the mine and mill last summer consisted of twelve
ove and nine under ground, a smith, five mill men and a
besides two cooks; and the aggregate cost of wages, with
t $30 per day. All employes were housed and fed at the
was no white man's habitation within several miles of Sultana
of the location however is finely situated for miners' dwell-
kely be used for this purpose. It is level, nearly surrounded
he soil is suited for making excellent vegetable gardens.

Working force of the mine and mill.

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ps of the batteries strike fifteen blows every second, and the sound made
n except to the finest ear. Yet by the arrangement of the cams on the
h stamp is raised and turned simultaneously, no two of them drop at the
e agitation of the water in the mortar is consequently as regular as the
mps, and the even vibrating flow which carries the crushed ore with it
over the face of the dies causes it to be reduced to a pulp, the fineness of
ed by escape through a screen of woven wire whose meshes number 1,600
The native gold in the ore is liberated by this milling process in whole or
the character of the ore and the fineness of the gold, and is amalgamated
the inner and outer plates. At the Sultana mill quicksilver is added to
rate of one-third to one-half a spoonful every half hour.

THE BURDETTE OR GOLD HILL LOCATIONS.

In the summer of 1885 Mr. D. B. Burdette of Bellevil
Minneapolis, employed a party of four men to prospect for gold c
side of Lake of the Woods. The district explored by them lies ab
miles in a straight line southeast of Rat Portage, having Big St
the north and Moore bay on the west. The Winnipeg Consolidat
on the shore of Big Stone bay, and had been worked to some exten
Several other gold-bearing veins had also been discovered in the sa
and eastward of it within a radius of twelve miles, two or three o
said to be large and well filled with quartz, carrying iron and cop
and some mispickel.[3]

Winnipeg Consolidated mine.

In his description of the Winnipeg Consolidated mine Mr. Cos
vein was found to be greatly varying in inclination, the dip at t
being 65° south, at forty feet 57°, at eighty feet 45°, and at ninety
again 65°. "At the depth of eighty-two feet two drifts had been co
the western drift was thirty-five feet in length and the eastern t
The true vein of massive quartz in these drifts as well as in the pit
to be narrow (6" to 2'); it is certainly auriferous, and I think rich ;
besides iron and copper pyrites, mispickel, a little calcite and a
galena and blende ; it follows the foot wall. At the roof the
amphibolite is changed into schist for one or two feet, and these
penetrated by small veins of quartz and impregnated with mineral s
they are taken out and submitted to the stamps in the crushing
the quartz. The crushing house is located on the shore of the la
600 feet from the pit ; it contains five stamps ; a long copper am
retaining plate, a grinder which receives all that passes over the
grinds it more finely ; and lastly a sort of closed pan, the inner
which is also amalgamated so as to retain the last particles of the
gold ; the refuse runs into the lake, carrying away all the non-f
gold."[4]

The mine here described was closed down in 1884 for want of
the mill is fast becoming a ruin. But the rich specimens of ore ta
the shaft together with the small quantity of bullion produced a
gave rise to a hope that other gold bearing veins might be found in t
besides those already discovered on the Winnipeg Consolidated and
locations. Mr. Burdette was one of the few inspired to prospect
of the lake, and he chose for his field of exploration a portion of cou

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[3] "A mile and a half east of the Winnipeg Consolidated mine, in the woods,
part of the property of that company, is another vein in which a small excavati
feet deep has been made. This appears to be a very good fissure, and the vei
filling it is massive ; it is quartz mixed with calcite, and is rich in iron and cop
with a little galena. The thickness of this lode is about five feet ; it strikes 16
east. About a quarter of a mile farther east in the woods, another vein about e
thickness has been purchased by an American company." E. Coste in Geo. S
1882-4, p. 12K.

[4] E. Coste in Geo. Sur. Can. 1882-4, p. 11K. Mr. Coste might have added that
mercury was allowed to run off into the lake also, for if one examines the bottom
inlet where the mill stands he will see that it is covered with pellets of mercury.
Matheson of the Hudson Bay Co. stated in his evidence before the Mining Com
"the mill was not well suited for its work, and the managers had not sufficien
of milling gold ore to make proper use of the equipment they had." It would s

The Burdette territory.

extent lying two miles south of the Winnipeg Consolidated Co's to the line of contact between the Huronian and Laurentian oore bay bounds it on the west, and several picturesque lakes lie ts. There are two ways of approach to the Burdette territory, anding of rocks at the Winnipeg Consolidated mill and the head of Moore bay, and either way the trail or road is about he location of the present works. The one most frequently is by the way of Moore bay, from which has been constructed nd a pole-road—the latter to facilitate the drawing in of heavy ired for the mill. Moore bay itself is reached from Big Stone narrow, winding, beautiful channel known as Eagle Pass, which ay island and the mainland.

Selection of locations.

tte's party of explorers consisted of F. W. Moore, Joseph K. Wright and George Dulmage. These men made a careful district selected for the purpose during the season of 1885. ere discovered by them, some of which were large and well nost all of which, it is claimed, showed free gold in the ore or pplication was made for eight several locations, to which fancy en after the manner of miners. One was known as the Ada the Combination, a third as Jerusalem, a fourth as Golden as Big Ellen, a sixth as Live Post, a seventh as Judge Mills as Golden Gate. All these lie in a block between Moore bay contact, but owing to the boundary dispute delay occurred in s. However in July, 1891, Mr. Burdette obtained patents ocations, covering an area of 458 acres. Four of these, viz.: res, 191P of 9 acres, 193P of 14 acres and part of 194P of 52 ded in one patent. The others, 175P of 58 acres and 70K of ld under separate patents. The rest of the area prospected was in the Mather timber lease, and the title to it is still in

THE NORTHERN GOLD COMPANY.

Organizing the Northern Gold Co. to work location 70K.

The formation and the veins

uired his patents, Mr. Burdette proceeded to interest a number capitalists in his enterprise, and in 1891 the Northern Gold rganized under the laws of the State of Michigan and stocked . The company acquired forty acres of location 70K, upon elopment work had been done in 1886. Six parallel veins rty in a formation of fine-grained mica-chlorite schist. Upon ar the northern side of the location, known as the Ada G. as started in the fall of 1891, eight by ten feet in size, which lepth of 50 feet. The vein is six feet wide and dips southerly 50°. At 35 feet the dip is said to change to 60° or 65°, but half filled with water I was not able to verify this statement. he vein is a fine-grained quartz, with some mica-chlorite schist, opper carbonate. The next vein, known as the D. B., is about of the first. It is four feet wide, and the dip is about the a G. Several openings have been made upon it towards the location, where it is capped with the country rock, and in

1892 a shaft was put down a depth of 50 feet. The third vein lies 45 feet south of the D. B. Like the others, it extends across the location, but is capped at the east and west ends, between which it passes through low ground covered with muskeg. Where it rises to the surface on the west side of the muskeg a trench exposes the vein to a length of 25 feet, and a shaft commenced last summer showed a well defined vein of four and a half feet, dipping southward at an angle of 75°. The ore is quartzite with mica-chlorite schist, the mineralized parts showing copper pyrites and traces of pyrrhotite. Fifty feet farther south is the fourth vein, outcropping two and a half feet wide on the surface; and the fifth vein is 200 feet beyond the fourth, with a width of two feet. The sixth vein is 100 feet south of the mill. At its western end it is covered by the waters of Islet lake, the southwestern boundary of the location, while eastward it is capped with the country rock. A vein having a north and south course has been traced by cuttings from the mill northward, and a shaft has been commenced near the crossing of the D. B. vein, where the formation is mixed and broken. At a depth of 20 feet the vein was struck and some ore taken out. But neither on this vein nor on any of the east and west veins does the ore show visible free gold.

Exploration work on the property.

It could hardly be said that real mining work had commenced on this location when I visited it in August. All that had been done to that time had for its object the proving of a number of veins, their extent, and the quality of their ores. Deep sinking would follow, and it was the manager's intention to at once commence such work on the two veins of best promise. One of these is the north and south vein, near the intersection of the D. B. vein. This is known as the No. 3 shaft, and although the formation is much the same as elsewhere on the property—being a fine grained hornblendic chlorite schist, but with more chlorite than hornblende, or possibly an altered trap—it has some time apparently been the scene of considerable disturbance. The ore taken from the shaft is quartzite stained by small quantities of silicate, and mica-chlorite schist with iron pyrites. In some samples very fine grained lustrous chlorite schist is included in the ore, and in others calcite.

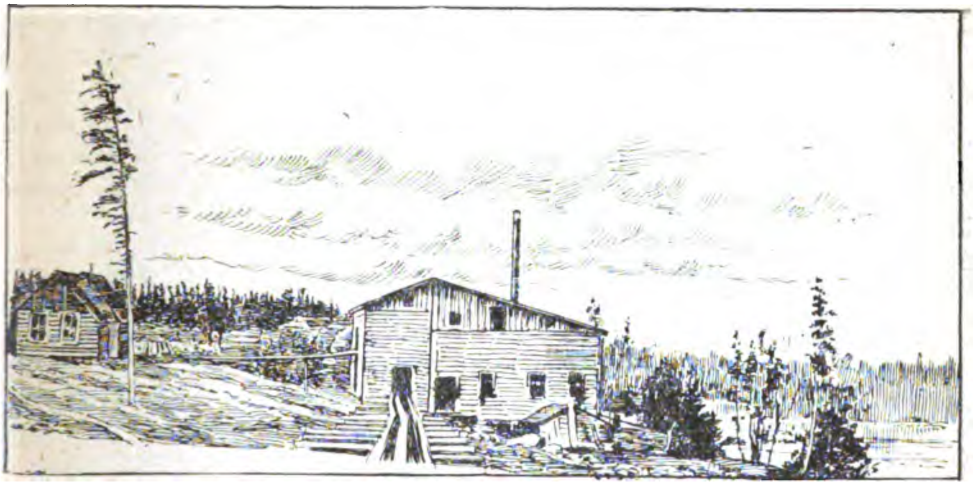
THE COMPANY'S GOLD MILL.

The mill and its equipment.

In 1892 the directors of the Northern Gold Co. became satisfied that the supply of ore on their location was ample enough to warrant the erection of a mill, and in the fall of that year preparations began to be made for one. The site chosen for it is at the northeast corner of Islet lake, between the rock bank and the water's edge. It is built of jack pine and cedar logs, the dimensions being 30 feet by 60 and three stories high. The basement floor is only half the size of the building. It is occupied with a 45 h.p. boiler and engine, made by Leonard & Son of London, and a set of chrome steel rolls for crushing the ore. The second floor is divided into two rooms, each about 30 feet square, one of which is occupied by a Forster ore breaker, and the other as first fitted up by a Gates pulverizer, a copper stirring tub, a pair of Cook amalgamators and a pair of Leede furnaces for roasting ore. The third floor, which is on a level with the rock bank of the lake, was furnished with a set of steel finishing rolls, two sizers or sieves, and tanks to hold a supply of water for the boilers and amalgamating tubs, and for fire protection purposes. A small force pump raises the water to these tanks from the lake, and the supply will always be ample for the needs of the mill.

Process of treating the ore.

An elevated tramway has been built from the mill to the shaft on the Ada G. vein, over which the ore is delivered from the several shafts to the breaker on the second floor. This machine has a capacity of 65 tons per ten hours, reducing to the size of a four-mesh sieve. From the breaker the ore is lifted by elevators to be fed into sizer No. 1, and the portion of the charge passing through it goes by a spout to the rolls in the basement; the coarser lumps are returned to be fed again into the breaker. In the chrome steel rolls the ore is reduced to a twenty-mesh, and is conveyed thence to the finishing rolls on the third floor. Here it is ground to a fineness of fifty-mesh and passes through sizer No. 2, to be reground if necessary in the same rolls. So reduced the charge is conveyed to the copper stirring tub on the second floor, where it is thoroughly mixed with water and discharged over galvanized copper plates for the last process into a pair of Cook amalgamators—quicksilver having been placed both in the stirring-tub and on the plates to take up the free gold.



4. Northern Gold Company's mill; office and assaying rooms to left, and Islet Lake to right.

The Cook amalgamator.

The Cook amalgamator, an invention of Dr. Henry Cook of Colorado, consists of a drum of boiler iron three feet long and twenty inches diameter, with an interior iron spiral having a length of forty feet. One-third of this spiral is silver plated on copper for collection of the floured mercury and fine gold. The drum revolves at a rate of thirty per minute, and the pulp having been carried the whole length of the spiral is delivered on silvered copper plates in which are wells to catch the amalgam. There is no saving of concentrates, if there be any in the pulp, and the water carries the tailings from the last series of plates down a sluice into the lake. The action of the Cook amalgamator, it is claimed, imitates panning. "The circular motion given to the pan," Dr. Cook says, "holds the gangue in such a state of suspension in the water that the mineral is allowed to gravitate to the bottom.

The circular motion of the cylinder accomplishes the same result. To finish separation of the mineral and the fine heavy gangue remaining with it, a small quantity of water is made to flow by a circular motion around the inner edge of the pan, which carries away the fine and heavy particles of gangue, leaving the mineral free, and if mercury is present the particles are all united. The circular action of the cylinder accomplishes the same result." The machine has a capacity of 12 to 15 tons per day of twenty-four hours, weighs 500 lb., requires 18 gallons of water per minute, and is driven by one-eighth horse power.

THE LEEDE ROASTING FURNACE.

Merits of the Leede furnace for roasting ore,

A special feature of the Northern Gold Co's mill as first out-fitted was the Leede furnace, a pair of which were set up for roasting the ore before subjecting it to the rolls. This furnace is the invention of Julius Leede of Minneapolis, and the claim made on its behalf is that it imitates the process of nature in oxidizing the ore and so brings it into a free-milling state. Gas made from crude petroleum supplies fuel for the furnace. In the production of it the oil is fed into a chamber where it is agitated or "atomized" by air blown into it through a set of perforated tubes, in which condition it passes into a retort maintained at red heat and is there converted into gas. The furnace itself consists of an upright cylinder of rolled plate, of two feet diameter and six feet height, divided into an upper and a lower section by a trap diaphragm, and having an inner slitted cylinder of about fifteen inches diameter to hold the ore. The gas is forced out of the retort through tuyeres at the base of each section of the furnace, where it is ignited and the ore is subjected to a flame of intense heat. In the annular space are a series of perforated tubes from which jets of water play upon the ore at short intervals through the slits of the inner cylinder, whereby, according to the idea of the inventor, nature's process is pursued of oxidizing the ore by the combined agencies of heat and moisture, and the sulphur, arsenic and other refractory constituents are carried off in a gaseous state to be recondensed as bye-products in a cooling tank. At the start the upper section of the furnace is filled with ore as it comes from the breaker, and when treated for a certain time the charge is dropped through the trap into the lower section, where it undergoes the process again and becomes converted into free ore, ready for the pulverizer and the amalgamator.

in theory and practice.

Such is the Leede furnace in theory, with a capacity of roasting 30 tons per day of twenty-four hours. The officers of the Northern Gold Co. had witnessed the performance of an experimental plant set up and tested under the eye of the inventor at Minneapolis, and confidence in its suitability for the work was shown by their ordering two furnaces for the new mill, together with a supply of nearly 200 barrels of crude oil for fuel.

The mill was started on the 23rd of July, but the Leede furnace was a grievous disappointment. The generator could not produce enough gas to roast $3\frac{1}{2}$ tons of ore per day, and after a futile attempt to induce the inventor himself to visit the works and direct the operations, a meeting of the directors was held and orders were given to reconstruct the mill. The Leede plant

The mill reconstructed.

, the pulverizers and sizers were removed, and a ten-stamp mill county pattern was procured in their stead. But it was near the ear before the alterations were completed, and there are no report.

OTHER GOLD HILL PROPERTIES.

Keystone vein.

the head of which is in the eastern part of the Northern Gold Co's eastward about half a mile to Granite lake, a small body of water tact line of the Huronian and Laurentian formations. The south vine is near the lake a steep cliff of mica-chlorite schist about ninety is cut from top to bottom by a vein thirty feet wide, which is Keystone. This vein has a north and south course, dipping tward, and consists of white crystalline quartz with fine grained lcite, carrying copper pyrites and films of carbonate of cop- ll rock appears to be a fine grained chlorite or mica-chlorite is more or less mixed with the vein matter. A granite dyke eight s across the vein and the country rock, having an east and west bout seventy-five yards nearer Granite lake is a quartz vein six wide, running north and south. The Keystone vein is traceable ridge about a quarter of a mile south and disappears under nd. Beyond this low land what seems to be the same vein is and may be followed to the shore of Gold lake on location 190P, he northern outcropping at Granite lake.

A series of veins on Gold Lake.

a number of veins on location 190P, on two or three of which ting work has been done. On one of these, the Combination vein, unk by Frank Moore five years ago to a depth of 56 feet, and it t good samples of ore were taken from it. The vein is seven ns northeast and southwest, and dips towards the west. East 00 yards is a parallel vein eight feet wide, and 100 yards farther ieved to be the Keystone, seven feet wide. Seventy yards west ination is a decomposed vein three feet wide, having an east and and 100 yards farther on is a like vein eighteen inches wide. All un into Gold lake, a beautiful sheet of water enclosed on all nse greenwood.

several other veins on properties explored by Mr. Burdette, one the Judge Mills location is about twenty-five feet wide; but as they do not carry gold.

The Black Jack Mining Company.

The Bulldog mine.

ocation 90x, known as the Bulldog mine, adjoins the property ern Gold Company on the west, while north and west of it are of the Canada Consolidated and the Winnipeg Consolidated It consists of 336 acres, and the Crown patent was issued in liam J. Franks of Toronto. Mr. Franks prospected it to the extent wn a test pit on a northeast and southwest vein to a depth of h is said to have assayed $8 to $14 per ton. In the fall of 1892 this location was purchased by the Black Jack Mining Company, composed of Duluth and other Minnesota capitalists, with Parlan Semple of Oshkosh as president, E. Brown of Duluth as secretary-treasurer, and E. B. Barnes as general manager. The Company began operations by putting down a shaft 11 by 7 feet on the southern part of the property, at a point on a bluff about 300 yards north of Islet lake and 100 yards from the eastern line of the lot. The vein lies in hornblende schist, is about 8 feet wide, and is composed of quartz and mica-chlorite schist. Samples of the ore show it to carry copper pyrites and small quantities of pyrrhotite. On the 17th of August the depth of the shaft was 63 feet. It is perpendicular to a depth of 20 feet, and then dips south at an angle of 75°. At 52 feet a drift has been opened east and west on the vein about 18 feet, and a cross-cutting 9 feet north and 3 feet south which shows vein matter throughout. At that date mining operations were carried on with a small force and prospecting pits were being sunk on other veins, some of the ore showing free gold. In the winter of 1892-3, a small mill building was erected at the foot of the bluff near the shaft. It is built of round logs, the main portion being 30 feet square, with an engine room 18 by 25 feet, and a crushing room 16 feet square on the bank attached to the main building. It was equipped with a steam engine and boiler of 40 h.p., two Crawford mills, and a Blake crusher with a capacity of breaking 20 tons of ore per day of ten hours to half inch size. Only one of the mills was tried and 50 tons of ore were run through it in a week, but the work was not satisfactory. It is admitted that the free gold was extracted, $300 having been saved from the run, but that the gold in the sulphurets was not touched. Charles Brent was in charge as superintendent and assayer, with four miners, engineer, teamster, and cook; but I learn that operations were closed early in the fall of the year, owing to the financial stringency in the States. There are numerous veins on the location, and it is probable that the work of developing them will be resumed when money gets easier.

Developing the property.

Testing the ore with a Crawford mill.

PINE PORTAGE MINE.

Location of the Pine Portage mine.

A property which made some stir in the Lake of the Woods district ten years ago is known as the Pine Portage mine. It is easily reached from Sultana island by paddling up to the head of Pine Portage bay, south of the island, a distance of about three miles, and then following the road towards Rossland about half a mile to the old camp built when operations were active at the mine. A road leads southward from the camp between two ranges of rock which at a distance of 300 yards open out into a spacious valley, with the Huronian schists on one side and the Laurentian granite and gneiss on the other. At the head of this valley the mine was located, and a mill and all other necessary buildings were erected alongside a little stream which has its source not more than 200 yards above. Referring to this enterprise in the Geological Survey report of 1885, Andrew C. Lawson said:

Early records of the enterprise.

"The Pine Portage mine, the most important and most promising venture in the district, was worked steadily throughout the summer of 1884, there being about a dozen hands employed. The shaft was sunk to a depth of 100 ft run to a considerable distance to the south. The ore was ıs taken from the shaft. In 1885 very little work was done at it is, I believe, the intention to continue operations during the , the aspect of the vein and the character of the ore being fairly · as developed, and warranting the vigorous prosecution of the he reason assigned for the suspension of work is largely the ıntered on the part of the proprietors in securing a thoroughly experienced mining engineer to take charge of the operations ıd their reluctance in the light of experience to enter upon any outlay till such a manager can be procured. The position ›roprietors of the Pine Portage mine is a sound one, but one o prominence the fact that in Canada or the adjoining States mely few practically trained mining men, who, in addition to e of the economic management of the works and mine, possess also ıprehension of the problems concerned in the extraction of the ll enable them to study to advantage the milling of new ores and devise methods of treatment for particular cases which will ıs loss in the tailings, such as has been the aggravating experiıe Portage mine." [3]

Why work was suspended

Character of the vein.

of the vein is a point west of north and east of south, and it red on the surface by an open cut for a length of 50 feet in lendic schist, the hanging wall rising about 70 feet above the ft sunk at the southern end of the open cut is now filled with hows a dip of about 75° to the east. Mr. Lawson, who had of examining the mine while work upon it was in progress, ead as a fissure cutting a hard massive schistose hornblende nce of only 150 feet from a granite mass towards which it dips, to the contact of granite and schist. "The dip of the Pine owards the granite mass at so short a distance to the east of it the mine that may develop interesting facts as the work proextremely difficult to discover whether the granite actually erior position to the schist, or the reverse. If the former is aft, if continued at its present incline in the vein, would strike the schist and granite at no great depth, and the analogy of ›st successful mines would warrant the presumption of a conıetallic material in the neighborhood of the contact of two such with the juxtaposition of which is so evidently associated the e lead." [4]

Present condition of the property.

e of the seemingly good promise of this property, it has lain t ten years. One of the principal owners, Mr. Thomas W. nburg, claims to have expended $25,000 upon it, and his conılue remains unshaken ; but others are not so sanguine, and aid, to put up their share of the money required for a thorough It would certainly be very interesting to know the character the line of contact,—if it continues into the granite and is

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Canada : Report on the Geology of the Lake of the Woods region, 1885,

[4] Ibid, p. 143 cc.

mineral-bearing in that formation, and if at the contact there is any enrichment of the contents of the vein, as is often found to be the case in such circumstances.

The mill which was built to treat the ore of this mine is already a ruin. It was supplied with a steam engine from Erie City Iron Works, a Fraser and Chalmers stamp mill and a pair of Frue vanners, and these remain as if waiting for the mine to start into life again. But one wonders why such a mill should have been erected on a brooklet whose channel is dry half the year. Obviously enough, and for more reasons than this one, there was need of the service of a competent engineer to manage the affairs of Pine Portage mine.

THE RAJAH MINE.

A mining property in Jaffray township.

The Rajah mine is on location 317P, about five miles northeast of Rat Portage, and consists of 131 acres. By the recent survey of the township of Jaffray it is found to occupy part of lot 13 in the seventh concession of that township. A colonization road intended to connect Rat Portage and Rossland runs about three miles south of the location, from which it is reached by a very good road over a belt of burnt land. The Rajah Gold Company of London, Eng., acquired the property early in 1892 from Messrs McGee, Brereton and Henesy, the joint discoverers, and made arragements to develop it. Bands of hornblende schist and gneiss cross the location from northeast to southwest, rising to a height of 150 feet above the valley on its western side. The vein runs with the course of these bands, and has been traced about one-third of a mile across the location; but about midway an east and west gorge makes a break in its continuity, which is covered over with debris and soil. At the northern end a shaft 7 by 9 feet has been sunk to a depth of 60 feet. The dip of the vein is about 85° to the northwest, and the hanging wall is well defined from top to bottom of the shaft. At 36 feet a gallery was driven southward on the vein a length of 47 feet from wall to wall, the average width of which was found to be about 5 feet. The ore is a fine-grained quartzite in bands of blue and white, and carries iron pyrites. It is stated that assays made by Mr. Hille of Port Arthur showed an average of $15 in gold and silver per ton. On the southern side of the gorge a shaft of 7 by 9 feet has been sunk to a depth of 63 feet, and work was in progress at the date of my visit (August 19th). It is mostly hard hornblende schist, containing however a band of quartz which varies in thickness from 3 feet to 10 inches, the latter being its width at the bottom. Assays are claimed to have shown as high as $200 of gold and silver, but the prospect is not at all promising. At the break in the vein made by the gorge an opening was being made at the time of my visit, and samples of ore taken out showed it to be composed of banded quartzite, with some limonite and tourmaline. A force of nine men was employed, under the management of M. T. Hunter, and operations had been carried on steadily since the first of December, 1892. The London Company sent out an old and experienced expert, Mr. W. B. Pascoe, to examine the property last summer, and he collected many bags of samples to assay upon his return to England. It is understood that Mr. Pascoe's report has been decidedly unfavorable, and that the Company has ceased operations.

English capital interested in it

Extent of mining operations.

THE EL DIVER MINE.

A mine in the Laurentian formation.

e is reputed to be an English refinement for hell diver, a bird s having been seen on the stream which crosses the property spector made his discovery. The location is 2¼ miles north of ion, and due east of the Rajah mine, a portion of it being on lot ne concession in the township of Jaffray; but about two-thirds unsurveyed district east of the township. The owners are Mr. er, a lawyer of Cleveland, Ohio, and Mr. E. W. Gaylord of necticut. It is known as location 351P, and contains he easiest way of reaching it is by boat from the head of t Rossland—a beautiful sheet of water which overflows into eon lake. Paddling a mile and a half northward a land- l at the rear of Burnt island, from which an excellent er a tract of gravel to the mining camp. The east side of the obscure gneiss, but towards the north and west it is traversed ge of hornblende slate, the surface of which shows evidence of g. There are two northeast and southwest veins in the gneiss, ides of a creek which runs northward to Black Sturgeon lake, yond the location. The gneiss rises in rounded bosses on either reek, and along the line of the veins it is cut by numerous ne to five inches wide. The No. 1 vein, on the east side of the een sunk upon by a test pit to a depth of 8 feet, where the n to be about three feet. Separated from it only a few feet is a f iron ore. Another opening, made about 50 yards northward, body of ore containing a variety of minerals. Specimens are sist of magnetite, impure pyrites weathering into limonite, te mixed with a silicate, possibly hornblende or pyroxene. the opposite side of the stream, 100 yards northwest, crops out ow stringers across a rounded hill of gneiss, and here a shaft n built and a shaft 7 by 9 feet sunk to a depth of 102 feet. s filled with water, and my information concerning it and all ne on the property was gleaned from Mr. Gaylord, one of the h walls are in gneiss and the dip is northwestward about 80°. e, as stated above, there is only a showing of stringers, the vein with the country rock, but at a short distance below it is found etween the walls, and this width is maintained to the bottom nge. The quartz in the vein pinches and widens irregularly es to 4 feet, but it was found to be continuous. At 70 feet it e hanging wall, but at 85 feet a cross-cut of 6 feet was made n was again found to be 4 feet wide. The quartz, or rather f a bluish tinge, stained with silicate, and is impregnated with The wall rock is a coarsely crystalline gneiss.

Development work.

nter of 1892-3 an American pulverizer was put in to treat the cloth apron vanner to concentrate the pulp; but the process ssful, and in the spring of 1893 a Crawford mill was introduced. started in April and was run four weeks. Mr. Gaylord says it e very satisfactorily in all respects except as to quantity of work.

Milling the ore.

Instead of milling 8 tons per day of 24 hours as claimed by the manufacturer, it only milled 5 tons. And now comes the curious part of the narrative. On May 31 the mill was cleaned up, and the amalgam was left in an open kettle inside the building. That night the building was destroyed by fire. On examining the contents of the kettle it was discovered that they had been strained, as the total quantity of quicksilver put into the mill was 240 lb., and the quantity after the fire was considerably less than 200 lb. The wonder is that after passing through the fire there should be any of it left. However, according to the statement of Mr. Gaylord, there is no doubt in the mind of the owners that the gold in the amalgam was stolen, and that the mill was fired to hide the theft. The engine which drove the Crawford mill and also the hoisting engine was badly damaged by fire, and mining operations on the El Diver were thenceforth discontinued.

The mill destroyed by fire.

THE TREASURE MINE.

The Treasure mine is on locations 400P and 409P, two miles southwest from Rossland station, comprising 160 acres. It is owned by Messrs. Webster and Angell of Cleveland, who have done considerable prospecting work. There are two strong veins on these properties, each of which has a northeast and southwest course. The country rock is a coarse grained granitoid gneiss, and also felsite, a very fine grained and distinctly laminated light gray rock. No. 1 vein is well exposed on the western bank of a depression or gorge which crosses the locations, and numerous stringers run into it, one of which has yielded many samples showing free gold. The fissure of the main vein at the surface is filled with felsite, and near the top of the bank it divides into two veins, the main one continuing in a southwest course with a width of 6 feet, and the smaller one diverging south-southwest with a width of 2 feet. At a point 40 feet below this divergence (or junction) a shaft of 7 by 9 feet has been sunk to a depth of 60 feet. At a depth of a few feet the felsite gives place to quartzite and interbedded mica-chlorite schist, with a little iron pyrites distributed in thin plates or leaves in the fissures. The vein dips towards the southeast, and as the shaft was sunk perpendicularly the lower portion of it is in the country rock. At 50 feet a cross-cut of 36 feet was made which struck the vein at 6 feet from the shaft, showing a width of 7½ feet of banded quartz and schist. The shaft on No. 2 vein is also 7 by 9 feet, and has been put down to a depth of 50 feet. The characteristics of the vein matter are the same as those of No. 1, but with more iron pyrites. It is lined with a selvage of mica-chlorite schist and sericite schist on the foot wall; the hanging wall was not exposed by the shaft, but the vein towards it was well mineralized.

Locations of the Treasure mine.

Character of the veins.

OTHER LOCATIONS IN LAKE OF THE WOODS DISTRICT.

There are many other gold locations in the Lake of the Woods district, on some of which a little prospecting work has been done; but most of them are held for a speculative object. Bad mine, 349P, consisting of 40 acres, is three-quarters of a mile south of Rossland; M. M. Holmes of Rat Portage,

Bad mine,

Test pits sunk upon the vein on this property have yielded
g samples of ore, nearly all of them showing native gold. Nor-
95P, is a mile south of Rossland, and is owned by Messrs.
Horne of Fort William, and Ross of Rat Portage. The vein
wide, with a course of northeast and southwest and a dip of
he southeast. A test pit was sunk upon it last summer to a
t 25 feet. On Pipestone Point, south of Hay island, in Lake of
some work undertaken last summer in the interest of Mr.
Winnipeg. Some samples showed the ore to consist of quartz
ites and mispickel; in others the mineral was weathered iron
o mispickel.

Norway mine and Pipestone Point locations.

Gold Reduction Works.

mining district like Lake of the Woods, where there is
pital to undertake mining operations as well as of experience to
ne often hears a wish expressed for such help to the industry as
might afford. With a mill that would treat the ore and extract
fixed charge or toll per ton, or that would purchase ore from
basis of valuation by sample lots, it is thought that owners of
r near the lake would be readily induced to develop and operate
inly a body of navigable water like Lake of the Woods—with
lands on many of which gold-bearing veins have been discovered,
s and inlets ramifying a large area of country, which on the
prospectors is a network of veins and fissures—such a water
tly favor the project of a custom mill, and ensure for it a plenti-
ore. But something more than a process of reasoning is required
e results are realized. Rat Portage has had its scheme of a
l, which has cost the municipality and a goodly number of its
thousands of dollars, and in the matter of results, carefully cal
and sanguinely hoped for, it has been a dead failure. I visited
he 18th of August, 1891, when a short test run was made for
on of a few interested visitors, and the notes taken then are
ed for the first time.

Utility of a custom mill in a new gold field.

The Rat Portage reduction works.

THE RAT PORTAGE GOLD AND SILVER MILL.

ke of the Woods Gold and Silver Reduction Company was
December, 1889, under the laws of the state of Illinois, as the
lling and Reduction Company, with a capital of $200,000.
mill was commenced in January, 1890, and in May of the same
ern was reorganized under an Ontario charter as the Lake of
old and Silver Reduction Company, with Robert Linn of Cleve-
dent, and Henry J. Powers as manager. At first it was
rect the mill on a site near Ross, Brown & Hall's sawmill, in
part of the town, and the municipality was induced to promise
0,000 when the mill was completed with a capacity to treat 30
nd silver ores per day. By a subsequent arrangement however

Organization of the Company.

the site was changed to the north side of Rat Portage bay, on the east side of the main outlet of the lake and convenient to the track of the Canadian Pacific Railway.

The mill

"The mill is a frame structure on a stone foundation, 147 feet north and south by 117 feet east and west, and 57 feet high above the first sill in the main portion, where the elevator and water tank are located. Work has been carried on until the present time, and the mill is not fully completed, owing to the non-delivery of part of the machinery.

and its equipment in prospect.

"There are two ore crushers with an aggregate capacity of 8 tons per hour—one known as the American, which treats 3½ tons, and the other as the Blake and Dodge, which treats 4½ tons. One per cent. is taken by an automatic sampler, which goes into a box and is pulverized and assayed separately. This forms the basis of the value of all the ore to the mill and to the producer or miner. The rest of the charge is raised by elevators to hoppers on a floor 40 feet above, to descend through chutes and automatic feeders into two pulverizers, known as the Standard. These are six feet in diameter, and enclose a steel ring of 4 by 5 inches, having a diameter of 5½ feet. Within each ring a muller plate is suspended upon a spindle or upright shaft, forming a movable bottom which may be raised or lowered at will. Resting flat upon each plate are nine rolls of 14 inches diameter by 4 inches face. In motion, the spindle revolves the muller plate, and it in turn drives the rolls by centrifugal force on the ring, against which they revolve in an opposite direction from that of the plate. While the charge of ore is entering the pulverizer from above in regular quantity through the automatic feeder, a supply of water is being delivered under pressure from below through the thin annular space between the plate and the ring. Now the same centrifugal motion which sends the rolls against the steel ring carries the ore in the same direction, and between the two hard surfaces it is gradually reduced to pulp. It cannot escape through the opening between the ring and the plate, being prevented by the upward pressure of water which keeps this space clear; but that pressure in the pulverizer gets to be outward as well as upward in obedience to centrifugal law, and the pulped ore issues through a screen which forms a portion of the enclosing wall of the pulverizer above the steel ring. All fine gold is carried out with the pulp, but grains too heavy to be floated drop through the space between the ring and the plate and are collected in the water chamber below. The screen has a fineness of 640 meshes per square inch, which is thought to be sufficient; but of course a screen of any finer mesh may be used if closer milling is found to be necessary for extracting the precious metal.

The process of treating the ore

to extract the gold or silver.

"The pulp from the pulverizers passes over a series of riffles in which the free gold is caught, and the tailings over concentrating tables, from which the concentrates are conveyed to the hopper of a furnace of three chambers. In the first of these chambers the pulp is dried; in the second it is partially desulphurized; and in the third of highest temperature the remaining sulphur is driven off, and if necessary the charge is chlorinated. From the third chamber it goes to a set of steaming pans, moistened by the addition of water and heated by steam to a temperature of 150° F. In two or thre hours sodium and potassium are added, and afterwards quicksilver, the whole being constantly worked and mixed meanwhile by the action of distributors in the pans. When this operation is finished the pulp is transferred to agitators, where it is diluted with water to five or six times, and is thence drawn off into settlers with escape discharges at top and bottom to divide the rich from the lean—the latter passing over concentrators to catch any particles of fine gold which may float off with it, and the former into clean-up pans to be drained off and put into trays for treatment in the retort, where the quicksilver is volatilized and recondensed in a cooler. The head is then taken off the retort, the contents of the trays are placed in crucibles, and the gold is melted and cast into bricks.

"Mr. Powers has been employed in mining since 1860 and in the erection and management of reduction works for eighteen years, having put up and operated mills in Colorado, Dakota, Wyoming, Arizona, New Mexico and Mexico."

The expectation and the reality.

Such was the mill on the eve of completion in 1891, when half hour trial runs were made under the direction of Mr. Powers to the delectation of visitors. The following subsequent account of the enterprise was given me last summer by Mr. Charles Brent of the Black Jack Mining Company, who had charge of the mill after the retirement of Mr. Powers:

Manager Brent's story of the mill in operation.

"The mill was completed in the fall of 1891, and the town paid over its bonus of $10,000 upon the assurances of a report made by Mr. Walpole Roland of Port Arthur, who had been employed for the purpose by the Council of the municipality. According to this report the mill was declared to be capable of treating 191½ tons of ore per day of twenty-four hours. As a matter of fact the only ore treated at the works under Mr. Powers' management was a lot of 75 tons from the Sultana mine, and 5 tons of concentrates from the Pine Portage mine. The average value of the concentrates was $80 per ton, but after going through Powers' process of roasting and amalgamation they still assayed $60 per ton. At the end of November a disagreement took place between the president and the manager of the company and the latter resigned. President Linn ran the works until Christmas, treating the Sultana ore, but he wasted about half the gold. I arrived in Rat Portage on the 20th of December and took hold of the management in the first week of January, 1892, and we ran through another lot of 75 tons of Sultana ore, finishing it about 15th January. I was not able to do better with the mill than my predecessor, and at a meeting of the directors it was decided to put in new concentrators and a chlorination plant. This was done; the mill was remodelled and docks erected at a cost of $15,000, which brought the total cost to this date up to about $75,000. Under the Linn and Powers organization shares had been sold to cover the cost of the works, the chief purchasers being residents of Winnipeg and Rat Portage. There was about $5,000 in the treasury when I took charge, and the balance of $10,000 was raised by the issue of debentures which were distributed pro rata among the stockholders. The improvements were completed and the mill started again in June, 1892. It was run for two months; but numerous stoppages occurred owing to the breakage of various parts of the pulverizers, until finally three machines broke down entirely and the works were closed. The concentrates were roasted in a reverberatory furnace and subjected to chlorination, but with very poor results on account of the quantity of metallic iron worn off the pulverizers. Experimental tests had given 90 to 97 per cent. by chlorination, but the largest extraction in actual running was not more than 70 per cent.

"The mill was closed about the end of August and has been idle ever since. It was sold under foreclosure of mortgage in January, 1893, passing into the possession of an American syndicate for $15,000. The intention is to put in four batteries of twenty stamps and resume operations, but owing to financial distress in the United States the undertaking has been delayed."

CUSTOM MILLS AND SMELTERS IN COLORADO.

The lesson of the enterprise.

The story of the Rat Portage reduction works is only one more instance of the folly of adopting new processes on a large scale before they have been tried and proven on a small one, and unluckily it is usually on new gold fields that new-fangled methods are most readily taken up. But the failure of the attempt to establish a custom mill at Rat Portage does not prove anything against the utility of such a scheme to assist mining enterprise or development. Concerning their operations in Colorado, I obtained the following information from Major Long, who had charge of the Cook amalgamators at the Northern Gold Company's mine last summer:

Custom stamp mills and smelters in Colorado.

"In all gold camps of Colorado," Major Long said, "custom stamp mills are erected for treating ores, and there are custom smelters at Denver, Pueblo and Leadville, and two at Durango. The stamp mills range from 80 to 125 stamps per mill, with a daily capacity of 1½ tons of ore per stamp. They are owned by companies, and as a rule a company owns only one mill. State aid is never given to a mill, neither is municipal aid; occasionally a municipality will give a site for a smelter, but very rarely a bonus. The state requires smelters and mills to keep a record of results, and this record is open to public examination. Every company is obliged to keep a record showing yield, whether it treats its own or custom ores, so that statistics of production may be obtained for public use. In stamp mills the practice is to charge for crushing, usually $15 per cord of eight tons. The free gold is caught on coppers, and the concentrates are dried, sacked and loaded on cars. Few miners have their own mills, the practice being to send the ore to custom mills. Often also the owner or owners of a mine will let workings under tribute, taking a royalty on the output. The advantages of the custom mill plan are that great care is exercised in the works, that good workmen are employed, that less capital is required, and that each mill aims to do its best possible work so as to secure custom. The concentrates and rich ores are sent to sampling works where they are sampled for the smelters. One lot goes to the assayer of each smelter and one to the owner, who, if he so desires has it assayed by a private or a State assayer—the report of the latter always governing the value in case of dispute. The smelting charge ranges from $6 to $22 per ton of ores or concentrates, which is deducted from the price paid for them. The bullion is never returned to the miner, but the value of it is placed to his credit."

THE OPHIR MINE IN GALBRAITH.

e in the township of Galbraith is reached by way of Bruce on on the Canadian Pacific Railway 449 miles from Toronto, and steamship via Collingwood or Owen Sound direct to Bruce way of Sault Ste Marie, according as one takes the Northern n or the Canadian Pacific Railway line of boats up Lake

THE OLD BRUCE COPPER MINES.

Copper lodes at the Bruce and Wellington mines.

e of Bruce Mines lies on the lake shore, upon a bay between nd French Islands; and it is noted for having been at one famous mining centre in Canada. The copper lodes which cut f greenstone here on the Cuthbertson mining location were 1849 to 1875, and the ore was either smelted on the ground or nd treated for shipment. The principal vein has a northwest course, extending from the lake shore east of the old village es for a mile and a half or two miles northwestward across the of the greenstone outcropping.

Old workings.

ngs towards the east end were known as the Bruce mines, and those est as the Wellington mines; but several smaller veins occur ons, from which considerable quantities of ore have been raised. ank at various points along the veins, some of which reached a athoms, and in places the ore was stoped out to the surface. as done the openings were covered over with timber and earth e safety and comfort of the miners; but the timbers are rotted ons of the roof have fallen in, showing gaps once filled with nd now filled to 25 or 30 feet of the top with rock and debris. ty of the veins is clearly exposed, as regards both size and width varies from 3 or 4 to 8, 10 and 12 feet or more, and neral course is maintained it is in places zigzag to a striking

Mills for treating the ore.

First mill.

Second mill and smelter

mines a small mill for treating the ore had been erected about m the shore, but old miners tell that it fell as soon as the works nd that three men were buried under the ruins. It was built rs which so thickly strew the ground over the greenstone ridge, t the remains one cannot but wonder what caused walls of such ness to give way. The second mill, also of stone, was erected irst and close to the lake shore. The main building is yet e addition which contained the crushing machinery is unroofed of the wall upon the west side has fallen. Two sets of Corn- worked here, into which the ore was fed by a large wooden ooden buckets on the inner rim, and after being crushed to the it was jigged to separate the ore from the quartz and other r of the vein. The jigs occupied a long frame building which west side of the crushing mill, and were worked over a series , 2½ by 6 feet. They were constructed of coarse wire, about 9 uare inch, and as they were shaken to and fro the ore sank to the bottom and dropt into the pit, the lighter gangue matter being meantime skimmed off the top. One boy could attend three jigs. The ore was afterwards removed from the pits and wheeled into a heap upon a platform south of the building, whence it was either taken to the smelter or loaded upon vessels for shipment to Wales. The engine which drove the machinery of this mill is yet standing in the main building. It is of the old Watt pattern, with a huge walking-beam 28 feet in length, and two balance wheels with massive rims of cast iron and a diameter of about 30 feet. A large and well constructed frame building stands upon the east side of the stone mill, which is known as the Yankee mill. It was erected for the purpose of testing an American method of treating the ores, but tradition says it ran only a few days. The manager of the works fell one night from the upper story to the ground floor and was killed, and probably this fatality had much to do with the failure of the process. The smelter stood on the lake shore, about 50 yards west of the mill. It ran for a number of years, but was partially wrecked in a gale of wind and afterwards destroyed by fire.

A sand bar of tailings.

The dump of tailings was on the lake side of the mill, but the waves have washed it into a sand bar which extends out to Crocket's island, about 200 yards from the shore. It is an evidence of the large quantity of ore treated at this mill.

The old village of Bruce Mines.

The old village was a busy place forty years ago, its principal street extending for half a mile along the shore of the lake. The dwellings were either log or frame, and most of them were small, being not more than 20 by 25 feet. All are deserted now, save one. Eastward of the mill stood a row of frame houses, including the Company's store and offices and a number of double dwellings, in front of which ran a well-paved street, now grown over with grass. At the eastern end of this street was the manager's house, which was the most imposing dwelling in the village. Numbers of the old houses have either fallen or have been torn down for fuel. One of these had served the double purpose of a church and a Sunday School.[5] A union church was subsequently built in the west end of the village, where service was conducted by Episcopalians, Presbyterians and Methodists; but it is deserted now. There was also a small Roman Catholic church in the place, which was moved west after the closing down of the old works, and it too has been unoccupied for many years. The best preserved buildings are the powder houses, which stand apart at some distance northeastward of the mines.

Mills a the Wellington mines.

The Wellington mines were supposed to be much richer than the Bruce, and were worked for nearly twenty years later. The principal openings are believed to be on the same vein as the Bruce mines, but large quantities of ore were taken from another vein farther south, about 200 yards from the lake shore. A small stone mill was built near this latter vein, and a larger frame one about half a mile to the northwest. A third mill of much greater dimensions was erected in 1872 or 1873 a short distance west of the old mill, in the centre of the new village of Bruce Mines. It is about 100 feet by 250, ick shaft is a land mark for miles out upon Lake Huron and up river.

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[5] The site of this edifice was pointed out to me by Sam Cullis, who said he had attended Sunday School there when a little boy. He passed through all the stages of a miner's occupation at the Bruce and Wellington mines, from jigger-boy to hammer-man.

Machinery of the new mill.

as crushed in Cornish rolls at the new mill, as in each of the ıd the steam engine was of the same design as that of the old ough not so ponderous; its walking beam is 25 feet in length. ere made in Lancashire, England, and bear the date of 1871. there were many works in Canada which manufactured engines any required capacity, but no doubt the English company was t they could not compare with the ones made in England for the ainly they did not in avoirdupois.

How the ore was treated.

cess, the invention of a Frenchman, was introduced at this mill er years of its working, by which the milled ore was roasted in , ten in number, and leached in wooden vats which stood in nder the low leanto roof on the south side of the building. Cer- were used in the leaching vats, but the cost of the process was the company is said to have lost $100,000 in one year. The tailings on the dump indicate the quantity of ore treated by

Gold in the tailings.

heaps of gray and brown tailings which surround the mill east- tward are some evidence of the extent of operations at the Bruce on mines; yet the piles now remaining here are but a small por- ole, as hundreds of train loads have been carried off to ballast the anadian Pacific Railway. It is currently reported that these tail- d, and that several recent assays show it to run from $2 to $7 per o said that one or two parties have been anxious to purchase the object of setting up a plant to extract the gold, but that the ıny thinks it has more value for ballast. A well founded tra- at the presence of gold in the Bruce and Wellington locations one or two of the old miners. William C. Dobie, police magis- Arthur, has informed me that it was discovered by his father-in- more veins, and that he had reported the fact in a letter to the the company, and that for his pains in so doing he was advised roper business. The discovery of gold in the township of Gal- erefore not a startling surprise to some of the old employés of l Wellington mines.

An early discovery of gold ore.

THE OPHIR GOLD MINE.

From Bruce Mines to Galbraith.

ce Mines to the Ophir Mine the distance is usually computed at as measured by the length of telephone wire put up on the road t is found to be 18 miles. It is an old colonization road, on of the employés of the copper mines and their descendants have mers, and it traverses a number of rich sections of farm land und the lake basins and along the river valleys. After running erly direction about 3½ miles across the Cuthbertson location, a 0 acres, the road cuts through the northwest corner of lot 4 in cession of Plummer Additional, and thence through lot 4 in the n of Plummer to Ottertail, a hamlet at the lower end of a lake of that name where the Thessalon river issues on its way southeastward between high hills of red and white quartzite towards Lake Huron. Winding around the south end of Ottertail lake, the waters of which have been lowered for the purpose, the road crosses a wide peaty bottom and ascends a band of white quartzite hills to trend northward along the line between lots 2 and 3 in Plummer to Coffin, and thence eastward and northward to the townline between Coffin and Galbraith, where once more it enters the valley of the upper Thessalon, near the junction of its east and west branches. Turning south on a newly built road across the east branch, half a mile brings us to the Ophir location. This is composed of the south half of the north half and the north half of the south half of lot 12 in the third concession of Galbraith, having an area as was supposed of 153 acres.

Improving the road to Ophir Mine.

The road as far as Ottertail has long been in excellent condition, but beyond that hamlet it was until last year very rough and heavy for the greater part of the way and badly cut up by traffic to and from the lumber camps upon the head waters of the Thessalon, Echo and Mississaga rivers. Little or no statute labor had been put upon it by the settlers since the time of its early construction because, as they claimed, the lumbermen did most of the travel over it and contributed nothing for its maintenance. But with the development of the Ophir mine repairs became a necessity, as in the old state it would have been impossible to carry in the supplies and machinery required at the camp. Accordingly the Ophir Company undertook upon its own account to make the improvements called for by the condition of the road, and $2,000 was expended in making the worst sections passable. This with a grant of $1,200 by the Ontario Government has sufficed to put the road in substantial shape, and until the heavy October rains began to fall it was as good for wheeling as many roads in the older settlements. The successive ranges of rocky hills which cross the country, usually in a southeast and northwest course, but in places with awkward irregularity, make steep and long grades unavoidable, but inasmuch as no road allowances have been laid out in the survey, five per cent. of the land being reserved by the Crown for this purpose, the most feasible routes consistent with a general course along the surveyed lines are taken for road construction. The abundance of gravel beyond the Thessalon river furnishes material for excellent road building; and although level roadways are unattainable, it is quite practicable to make them first class in every other respect.

Geological relations of the district.

In its geological relations this section of country is one of the most interesting in Ontario. The junction of the Silurian and Huronian systems takes place in the channel between St. Joseph's island and the mainland at Bruce Mines; and after crossing the band of greenstone at the latter place, the breadth of which is not more than a mile, we travel for a distance of not less than 15 miles over a series of formations which fold over each other in long succession to form what is known as the Thessalon trough—appearing, disappearing and reappearing in almost bewildering confusion to one who has not ample time to observe and study out their varied and interesting relations. And what adds to the perplexity of the task is the fact that some time in the long history of the Huronian age a dislocation occurred, whereby the forma-

›wn for thousands of feet out of the lines in which they had ‹ laid down. Murray estimated the total displacement at ıd his observations led him to believe that the line of fault ınce of about 40 miles, or from near Echo lake to the mouth of r.[*] Then again the crowns of the anticlinals have been planed ıl action, filling the valleys to great depths with sand, gravel at longer or shorter intervals the formations are cut by dykes r upheaved and contorted by mountain masses of syenite and wonder therefore if the geology of the country cannot be read or satisfaction in the course of a hurried drive across it, how- he observer may be.

Rock exposures en route to Ophir mine.

ruce Mines and Ottertail there are exposures of greenstone, stone, conglomerate and red quartzite; but farther north on f the Thessalon river there are ranges of jasper conglomerate ıdstone, chert and white quartzite. Beyond the river the road ccessive ranges of white quartzite, red quartzite banded with per conglomerate, white quartzite with bands of quartz con- quartzite, altered sandstone containing pebbles of granite and one and quartz syenite. The last named range is succeeded nother outcropping of white quartzite which extends from the Coffin to the low mountain of gray diorite which crosses the phir location on a northwest and southeast course. About a , on the farm of Mr. Moor, the quartzite and diorite abut con- ıst each other, as they also do upon a lower spur at the north- of the Ophir lot. The diorite escarpment is seen to extend for owards the east, where it rises about 300 feet above the bed n river.

Lake Ickta.

top of the tableland thus formed, and enclosed by high walls on its southeast side, is Lake Ickta, three-fourths of whose lies within the limits of the Ophir location, but without form- f it. It is a beautiful sheet of clear blue water, 300 feet in ed by numerous springs, a portion of the bottom at the south hores being quicksand. The outlet at one time was probably st side, where the beach is sandy and a valley opens out untain; but now it discharges a small stream through a gap its northwestern angle, the waters of which tumble down a ntil they reach the eastern branch of the Thessalon. There is ver that the discharge was through another gorge about 50 vest, when the level of the lake was a few feet higher than it h channels unite midway down the bluff.

Veins around Lake Ickta.

, where the water of the stream flows off quietly to the river, ccurs upon which a shaft has been sunk to a depth of 50 feet, it is filled with water. This is on an adjoining location to northern quarter of lot 12. Openings have been made at higher up the bluff, by which the vein may be traced eastward

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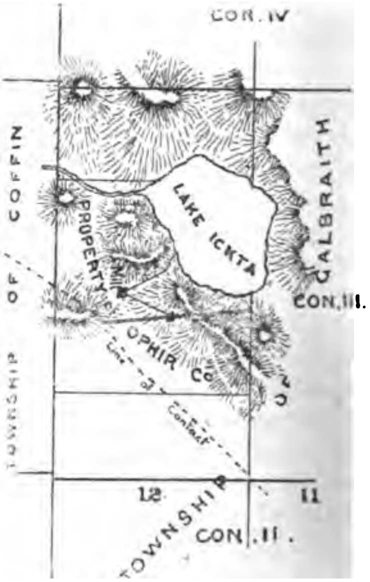
e a surprise if this fault was found in sections to be filled with mineral- r; but being covered with drift along the greater part of its length, no it appears yet to have been made.

through diorite to what looks like a horse of white quartzite, at an elevation of 100 feet above the shaft, and there all trace of it disappears under the mass of boulders which have fallen into the gorge. Eastward from the outlet of the lake about 75 yards, another vein of chloritic schist and quartz crops out at the waterline and is seen to extend in an easterly direction in the bed of the lake. There can be but a small portion of this vein on the Ophir location however, as the northern limit is only a few yards back from the shore; nor is it known to hold any valuable mineral. A vein of quartzite cuts the diorite for some distance eastward along the north shore of the lake, where the rocks show signs of not a little disturbance.



5. Ophir gold location.

The Ophir location,

Lot 12 in the third concession of Galbraith was computed in the original survey to contain 320 acres, whereof 307 acres was land and 13 acres water. A survey by Mr. Cozens, P.L.S., shows it to contain 324 acres, whereof 271½ acres is land and 52½ acres water. The total area of the lake is 65 acres, the balance of 12½ acres being in lot 11.

and the discovery of gold upon it.

The discovery of gold on lot 12 is said to have been made by William Moor, a neighboring farmer, but there are so many conflicting stories as to the discovery and the subsequent dealings with the lot that one may despair of getting a statement of facts upon which all the parties concerned will agree.[7] The portion known as the Ophir location, comprising the south half of the north half and the north half of the south half, was assumed to contain 153½ acres, but according to the Cozens' survey it embraces only 137½ acres.

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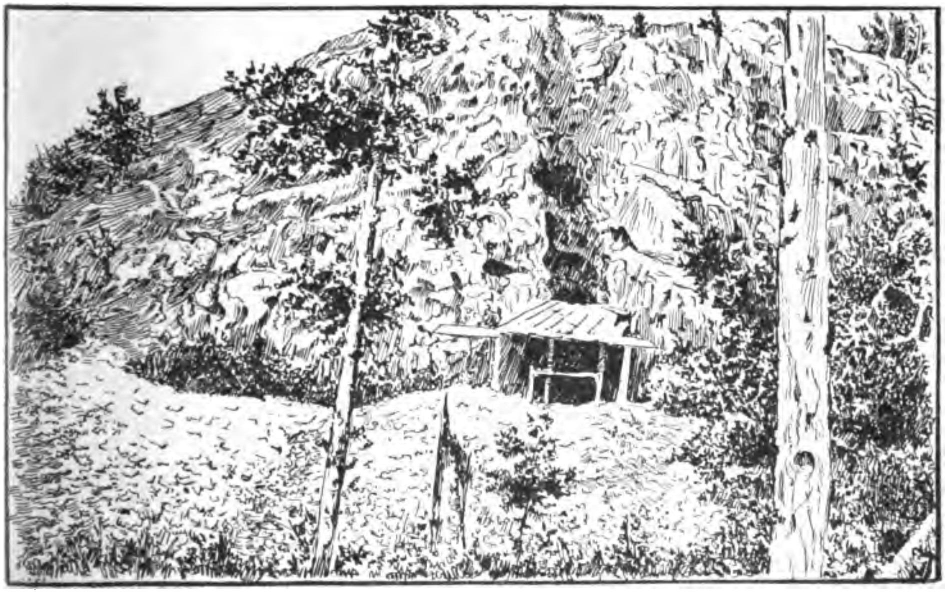
[7] The south half of the lot was purchased by Roderick Mackenzie from the Crown in 1883, at 20 cents per acre, subject to settlement duties. Mr. Mackenzie never lived upon it, but it was claimed that a portion of the duties was performed by his brother. As to the discovery of gold, the following affidavit is filed with the papers in the Crown Lands Department: "I, William Moor, upon oath declare that I live upon the north half of lot 11, con. 2, Galbraith township. That in the month of November, 1889, about the first, while prospecting, I found on the south half lot 12, con. 3, Galbraith township, specimens of ore containing silver ore or lead and gold. That I afterwards showed specimens to a man named Malcolm McLeod and gave him some of them, and they found their way into the hands of a man named W. J. Miller, residing in Thessalon, who came to me on the 12th November and asked me to show him the vein, which I did. He said he thought the discovery was valuable. He said he would open and work the same and pay all expenses and that I should have one-quarter interest, free and clear. I have worked between six and seven weeks on the lot under Miller's orders up to the 22nd day of January, and received seven dollars only from McLeod for same." Sworn before John F. Day at Ottertail, 4th February, 1890. This was filed in the Department by Moor to protect his own interests. Subsequently a similar affidavit by Moor, setting forth original discovery by him, was filed by Miller in proof of claim to the lot. On 7th December, 1889, Miller had applied to purchase the north half of 12 as mining land, and on the 17th he applied to purchase the north half of south half and the south half of north half. He obtained the patent for the north half of the lot, but the ruling in respect of the south half was in favor of Mackenzie, who transferred his interest in the north half of it to Alexander McArthur of Toronto. By a subsequent arrangement the McArthur and Miller interests were united.

Nearly the whole of Lake Ickta lies within its boundaries, occupying the northeastern quarter, but the lake has been reserved by the Crown. The mountain of diorite which encircles the lake shows a perpendicular bluff at the northern boundary of the lot, and extends in a southeasterly direction across it, throwing out a spur westward about midway in which the vein occurs. Another lower boss of diorite outcrops west of the bluff, where it comes into contact with the white quartzite formation, but the rest of the location is for the most part covered with rich black loam to the western boundary, which is the townline between Galbraith and Coffin.

The vein and its workings.

Where the vein has been worked it lies about 100 feet south of the dividing line between the north and south halves of the location, and has a course 15° south of west and north of east. The face of the spur looking westward is cleft from top to base by the vein, showing a dip southward of about 80°. Along the crown or apex of the spur the fissure is traceable eastward 175 feet, where it is covered over by gravel drift. Its width in this distance increases from 18 inches to 7 feet, and the vein matter changes from chloritic schist to quartz. On the western face of the spur the vein has a perpendicular exposure of 98 feet from the crown to the base, and it widens from 18 inches to 3 feet 4 inches, being filled throughout with chloritic schist. Here a shaft 6 by 8 feet has been sunk upon it to a depth of 90 feet, and at 85 feet it was found that the schist had given place to quartz in the vein. At the mouth of this shaft the vein is covered with gravel drift to a depth of 20 feet, but its course westward has been exposed by pits a distance of 1,185 feet to the line of contact between the diorite and the white quartzite, where it ap-



6. Ophir gold mine; showing fissure vein in face of the bluff, and mouth of the shaft; hanging wall of chimney on extreme left.

pears to be broken into stringers. A pit sunk in the drift at 1,000 fee shows it to be 3½ feet wide. On the northern slope of the spur there is very large outcropping or chimney of vein matter, extending around it like an arc of a circle. It is divided into three lens-shaped folds by bands of schist, whose greatest thickness is 43 feet. The workings show it to be connected with the fissure vein at both ends of the arc, its total length being about 400 feet. The point of junction at the lower or western end has not been definitely ascertained, but it is probably not more than 100 feet west of a vertical line from the base of the spur; the upper or eastern junction is shown by an adit to be about 225 feet from the nose of the spur. The upper and middle folds taper and run out towards the east, and an incline shaft 6 feet square sunk upon the lower part of it, 75 feet from the shaft upon the fissure vein, proves that they run out downwards also. The depth of this shaft is 105 feet, and being sunk upon the foot wall the dip is shown to be 40° south. This is maintained to 65 feet, when it changes to 50°, and it is at this point that the upper and middle folds thin out; it does not appear however that they are gold-bearing anywhere. The pay streak is in the lower fold, but it varies greatly; in some places the mineralized portion is not more than 4 feet wide, in others it is 16 feet, and in some sections the vein is barren. Four adits have been driven in upon the chimney at intervals above the incline shaft, the level of the fourth or top one being 115 feet above the mouth of the shaft. The first has a length of 80 feet, its course being 5° north of east. The second is 25° degrees south of east and has been opened to the roof; the vein has been worked out from wall to wall and has a thickness of 43 feet, and discloses a long wedge-shaped horse of diorite between the folds. Between the top of the chimney vein at this point and the fissure vein on the crown of the spur the thickness of country rock is 85 feet, and this apparently forms the hanging wall of one vein and the footwall of the other. The third adit is 75 feet, on a course 10° south of the east, and has been stoped out overhead 27 feet; its mouth is at the end of the upper and middle folds of the vein, and is 100 feet east of the opening of the second adit. At the mouth of the fourth adit the chimney and fissure vein join, and the quartz at this point is rich in free gold. This adit has a course 5° south of east; it has been driven in a length of 75 feet, and by a cross-cutting at 60 feet the vein is shown to be 16½ feet in thickness.

A record of operations.

Serious mining work was not undertaken upon the Ophir location until October of 1892. A number of shallow pits had been sunk upon the chimney vein, and at the lower end of it a shaft had been put down 10 feet. The owners had given an option on the property to a concern known as the International Development Company of Duluth, which also held options on several other properties in the district; but no work was done by it. A Chicago syndicate had been doing exploratory work on an adjoining property during the year, and it is stated that $25,000 was expended in sinking test pits in the drift with the object of discovering an extension of the Ophir vein towards the northwest, in the fond belief that it connected with a vein discovered 3½ miles distant, then called the Mudge property, but now called the Tiptop mine. Several pits were opened to a depth of 75 feet, but no vein was discovered there; the course of the Ophir vein, as was afterwards proven by Colonel Wallace, was nearly due west. But the operations of the Chicago syndicate served to keep alive the interest in the locality, and the Development Company induced a Duluth syndicate with A. E. Humphreys of that city at its head, to look after the Ophir. Mr. Humphreys was a successful lumberman, with no experience of mining affairs, but having with his associates been fortunate enough to secure the service of an old and intelligent miner in the person of Col. W. R. Wallace—who had discovered for them a valuable iron ore property on the Mesabi range in Minnesota—they were encouraged to find out what the Ophir location was worth. Colonel Wallace was sent to examine it in September, and his report being favorable the Ophir Company was organized to purchase the property for $100,000. Among those associated with Mr. Humphreys were George J. Atkins of Duluth, Frank Woodman of Charleston, W. Va, and George E. Milligan, then of Duluth but now of Chicago. On the 5th of October Colonel Wallace came to take charge of the development work as superintendent, when arrangements were made to clear off the land and erect the necessary buildings. Supplies were procured and mining operations commenced, the men boarding with farmers in the neighborhood until a boarding-house was completed on the 10th of November. Other buildings were constructed, including a dwelling for the superintendent; and as accommodations were increased additions were made to the force of miners and workmen. Nearly all the timber on the lot was cut down and cleared off, offices, dining hall, blacksmith's shop, etc., were built, and work on the fissure vein and chimney shafts was commenced and carried on throughout the winter. But when the spring thaw came on the shafts filled with water, and as no pumps were provided the superintendent set his men at work to open the higher section of the chimney vein by driving adits into it. In this way a large pile of ore was brought to the surface, and preparations were commenced for building a stamp mill.

The stamp mill and its equipment.

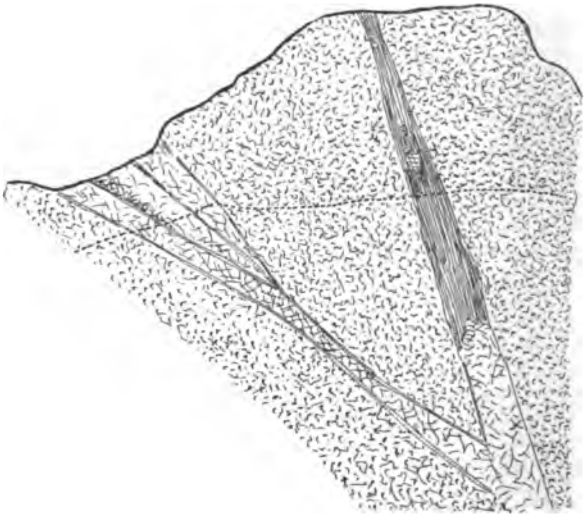
The contract for the mill was let to Messrs. Fraser and Chalmers of Chicago; but the excavations were made under direction of the superintendent, who also procured all necessary supplies of timber and lumber. Excavation work was commenced about the 20th of July, and the mill was started on the 9th of October. The main building is 58 by 81 feet, five stories high, with a wing of 37 by 46 feet for engines and boilers. The vanners floor, upon which are eight Frue vanners, is 37 by 58 feet, and 13 feet high; the battery floor, upon which are four batteries of five stamps each, is 37 by 58 feet, and 11 feet high; and the ore-bin and rock-breaker floor is 7 by 58 feet. A tramway from the latter floor connects with the ore-pile at the mouth of the first adit of the mine, and the ore is conveyed over it in iron cars by gravitation. The engine is a Reynolds-Corlis, built by John Doty & Co. of Toronto, and is 75 h p. Steam is supplied by two boilers of 120 h.p., which will also supply power for the mining machinery when required. The stamps weigh 850 lb. each; they are run at 85 per minute with a drop of only five inches, as the ore is easily crushed. The effective power of the four batteries is therefore 602,083⅓ foot pounds per minute, or 433,500 foot tons per day of 24 hours; and as the stamping capacity of the mill is 40 tons of ore per day, the power required to

Its working capacity.

crush one ton to the required fineness for extracting the gold is 10,837½ foot tons, or the equivalent of 61,200 stamp blows. Quicksilver collects the free gold in the batteries, on the plates, and in riffles on the vanners; the sulphurets, which carry gold, are saved and concentrated by the vanners for subsequent treatment, and it is claimed that not more than 50 cents of gold per ton is lost in the tailings. One battery of stamps was started on 9th October, and by the 14th the mill was in full running order.

Water supply. Water for the boilers and batteries is supplied from Lake Ickta, through a four-inch pipe 1,100 feet long. A No. 4 Blake pump, driven by a 10 h.p. boiler, lifts the water from the lake over a bank 46 feet above its level, from which there is a fall of 164 feet to a tank at the mill. Here it is warmed by exhaust steam from the engine, and is therefore of suitable temperature for the batteries in the coldest weather. The main pipe also delivers an ample supply of water for domestic uses in the camp.

Condition of the mill and mine as regards safety and health. My first visit to the Ophir mine was made early in the month of September, when the mill was in course of construction. I returned again in October, a week after the works had started. I found all parts of the mill to be in safe condition, as required by the Mining Regulations. The mine was also safe at that time; for although stoping work had been carried on to some extent in each of the adits, the roof was well supported by pillars and masses of ore. It was pointed out to the superintendent however that as the roof was evidently cut off from the country rock behind it by the fissure vein, so that it hung like a V-shaped body over the worked-out portion of the mine (see fig. 7), it would be necessary to put in ample timber supports before the ore bodies between the several adits were stoped out. In this view the superintendent fully concurred; but his connection with the mine ceased at the end of October. The sanitary condition of the camp is excellent. It could hardly be otherwise without criminal carelessness, located as it is on a slope of gravel drift, and bountifully supplied with pure water from the lake. The surrounding scenery too is picturesque and cheerful.



7. Ideal cross section of the Ophir mine; showing fissure vein to the right, and chimney to the left. The dotted line indicates the base of the bluff.

The Ophir Company was organized under the laws of Illinois, with a capital of $3,000,000, in 300,000 shares of $10 each. The stock was eagerly

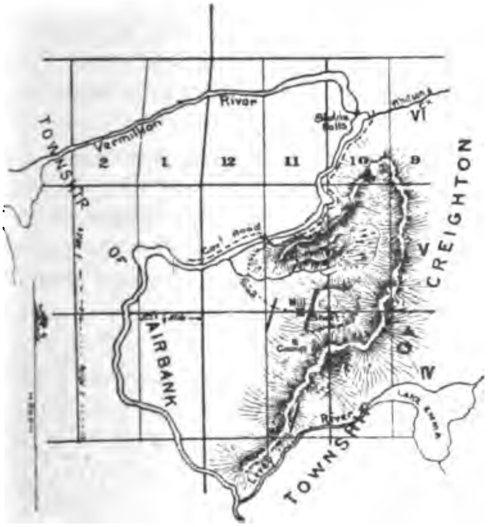
How the mine was stocked.

sought after at first, and large blocks were subscribed for by Americans who visited the mine and carried away samples of the ore. Numerous assays of these samples showed it to be very rich; but having been selected for their richness, no prudent dealer in mining stocks would consider that they represented the avearge ore of the vein. A mill test made at the Houghton School of Mines however was regarded as much more reliable. Three lots treated there, aggregating 5,170 lb.. were reported to yield 9.7 ozs of gold and 6.15 oz. of silver. On the strength of this report sales of stock were readily made in the spring of 1893, but the financial panic which swept the United States soon afterwards caused many of the purchases to be cancelled. For this and other reasons of an administrative nature, the Company has been working along under difficulties. The mine was absurdly overstocked, and this is a too common fault in Ontario, as well as elsewhere; yet there does not appear to be any sufficient reason for doubting that it is a good gold property.

THE CREIGHTON GOLD MINE.

Location of the mine, and how to reach it.

The Creighton gold location occupies portions of 11 in the fourth and fifth concessions of the township of Creighton, in the district of Algoma East. It is reached by a colonization road which is intended to connect Larchwood station on the main line of the Canadian Pacific Railway with Whitefish station on the Sault Ste. Marie branch, through the townships of Balfour, Creighton and Denison, and which is completed to the bridge crossing the Vermilion river on lot 12 of the fifth concession of Creighton. The road in Balfour runs through a section of very good land in the valley of the Vermilion river, but at Whitson creek on the sixth concession of Creighton a range of Huronian schists comes into view which extends easterly and southerly for many miles. From the creek to the bridge over the Vermliion the road skirts the foot of the range of hills across lot 10 in the sixth concession and lot 11 in the fifth, with the river flowing southward close to the right. From a point near the bridge the Creighton Gold Mining Company has opened a road southeastward around the rocky hills to the line between the fourth and fifth concessions and along that line to the mine, two-thirds of the way across lot 11. The hills form a semi-circle towards the north, enclosing a beaver meadow, and they sweep around eastward through lot 10 and south



8. Creighton gold location.

In a tract of Huronian schists.

towards Lake Emma and the Levy river, throwing out low spurs over the southern portion of 11 in the fourth concession, two or three of which are gray with splashes of quartz. This conspicuous showing of quartz is nearly on a line with the north and south vein on which the Company's shaft has been put down, but the connection has not been traced. On the west side of the location are two outcroppings of quartz which have a northeast and southwest course through low ranges of schist; but although some openings have been made upon them there are no clearly defined walls to denote veins. Here as elsewhere on the lot where outcroppings occur the quartz and the hornblende schist are closely mixed, as if they had undergone partial fusion, presenting a mottled appearance with white as the prevailing color.

Outcroppings of quartz veins on the property.

Exploratory work.

The location was prospected four years ago by J. R. Gordon, C.E., and exploration work was undertaken by him two years ago for a syndicate of Ottawa men which afterwards organized as the Creighton Gold Mining Company, with a nominal capital of $1,000,000. The site selected for sinking a shaft on the north and south vein is where the line between the fourth and fifth concessions crosses. The country rock of black hornblende slate has a north and south course and dips eastward at an angle of about 45°. The vein has the same course and dip, and although much broken at the surface it is shown to be contained within well defined walls below. The shaft has been put down to 160 feet, keeping close to the foot wall, and without change of dip in the whole of that depth. A selvage of soft slate varying from six inches to two feet in thickness lines the foot wall; the hanging wall has not been exposed, but by borings the vein is found to have a width of 17 feet. At 80 feet there is a drift or level of 12 feet, and at 130 feet another of 25 feet. The bottom 30 feet of the shaft is used as a sump to hold water, a large flow having been struck at the first level which demands the constant working of a pump. About 200 tons of ore was on the pile at the date of my visit (October 13-15) and the mine was in a condition for raising about 20 tons per day with one shift of miners. The vein matter is chiefly a bluish colored quartz, with markings of flesh colored felspar, and banded in parts with hornblende schist. There is no appearance of free gold in the ore, but numerous assays have shown yields of $4 to $20 per ton; the gold is said to be in very minute particles, calling for extreme care in treatment to save it.

Sinking a shaft.

A mill was erected last year close to the shaft. The main part is 24 feet square and 54 feet to the plates, three stories high. An addition of 24 by 30 feet and one story high provides room for a hoisting engine and machinery to treat the ore. On the second floor is an automatic feeder, and on the third a Doge crusher manufactured by Fraser and Chalmers of Chicago with a capacity to crush 40 tons of ore to the size of nut coal per day. The ore is raised to this story direct from the bottom of the shaft by a friction drum made at the Baldwin Iron Works, Ottawa. Water to supply the mill is also raised to a tank in the third story by a pulsometer pump. The engine house is attached to the mill, and contains a boiler of 100 h.p. capacity to work the engine, drill and machinery for crushing and milling the ore.

The mill.

The mill selected to treat the ore of the Creighton mine is one known as the Crawford Improved Gold Extractor. Many merits are claimed for it by

Testing the Crawford Improved mill.

and in Colorado it is said to be successful in saving a high the gold. But the one placed in the Creighton mill for some ealize expectations. It was started on the last day of my visit , under direction of Mr. Strickland of Peterborough, a represen- ventor; but much difficulty was met with in trying to get it nning order, due it was believed to faultiness in construction. ntity of ore treated was very finely milled, but stoppages owing s were too frequent for economic work. I learned afterwards was continued for a week without any improvement, when the l down pending the return to the country of the inventor, Mr. wford.

on the Creighton mine, including the putting down of the shaft, ts and erecting the mill building, has been done under the cy of Mr. Gordon. A substantial boarding house has also been cation.

Gordon Lake location.

the fourth concession of Fairbank, on the west side of the Ver- nd about two miles southwest from the Creighton mine, there is re of a quartz vein. This was explored in the fall and early by Mr. Gordon for an Ottawa syndicate, and an opening was illside to a length of 35 feet upon the vein. The property is Gordon Lake gold mine. The formation and the quartz out- the same as at the Creighton mine.

THE BELMONT MINE.

Location of the Belmont mine.

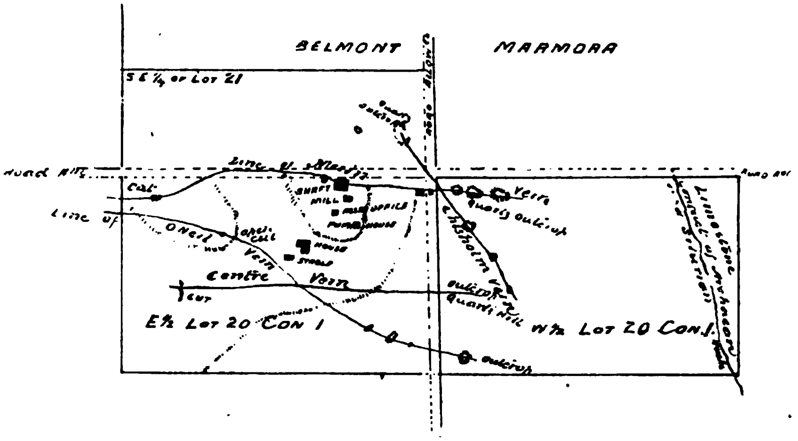
gold mine is in the township of that name in the county of , and consists of the east half of lot 20 in the first concession. n miles northwest of the village of Marmora by the highway, lace a railway track has been graded to an iron ore deposit upon location owned by T. D. Ledyard of Toronto. An area of calc s northward from the Silurian limestones to within a mile of , where it lies up against a wide band of diorite. The gold- are in the diorite, and have been traced near to the line of con- are three veins crossing the lot, one close to the road allowance nd lot 21 on an east and west course, a second parallel with it ddle of the lot, and a third on a northwest and southeast course ross the lot. The first of these is known as the Main vein, the Centre, and the third as the O'Neill. Another vein, known as , is parallel with the O'Neill, and extends from the southeast in the first concession of Belmont to the west half of 20 in the nora. The Main vein for a portion of its length underlies the ce between lots 20 and 21 of Belmont, but its course is very st and west. It is said that a party of the Geological Survey upon it for a fortnight several years ago without suspecting that ny value. The merit of discovery was reserved to H. T. Strick- borough, who while watering his horse by the roadside in 1890

The gold-bearing veins.

Discovery.

observed the vein, broke off some samples with his hammer, and found that they held free gold. The lot had some time before been located to a settler named Brown, whose widow was then in occupation. In July of the following year Mr. Strickland, with A. W. Carscallen, M.P., and Captain O'Neill visited the lot, took away some samples and had them assayed. The results were so good that terms were made with the occupant, the end of which was that Mrs. Brown took out the Crown patent and transferred all her interests to Mr. Carscallen. Exploration work was commenced upon the Main vein on 7th September, 1891, where a shaft was sunk, and open cuttings were afterwards made on the same vein at the eastern end of the lot, as well as on the O'Neill and Centre veins. At this time the location was held between Messrs. Carscallen, O'Neill, Strickland and Burnham, each having a fourth interest. Work was continued until 7th October, 1892, by which time 1,000 tons of ore had been raised, and the property was then let to Middleton Crawford for a year, at a rental of $100 per month and a royalty. Mr. Crawford brought on one of his own gold mills, and 210 tons which the syndicate had mined was put through as a first test. I was told by Mr. Carscallen that this yielded $9.53 per ton of free gold; and the concentrates, which were treated at Newark, N. J., yielded an additional $2.95. The average therefore was $10.93, and there is reason to believe that all the gold in the ore was not won. Mr. Crawford took out during his term about $5,000 of gold, and doubtless he would have been allowed to continue operations but for the conviction of the owners of the mine that his mill was letting too much of the gold escape in the tailings.

Exploration work on the property.



9. Belmont gold location.

The shaft on the Main vein was sunk to a depth of 132 feet. The gangue consists of white quartz with iron and copper pyrites. The iron pyrites occurs mostly in fine cubes, and in many places is enclosed with jaspery layers.

Prof. Chapman's report on the location.

Prof. Chapman of Toronto, who made a careful report on the property when the shaft was down to 122 feet, says the Main vein consists of a gangue of white quartz carrying a considerable amount of iron pyrites and a little and that for some depth from the surface it is decomposed into on oxide mixed with silicious matter and soil. The decom- d matter, he states, pans richly throughout the course of the idth of this vein at the surface is about 3 or 4 feet, or less in cending—as shown by the shaft, the only deep opening yet n—it widens to 12 and 13 feet; but suddenly, at a consider- ecomes nipped or pinched to less than a foot. The pinch con- 20 feet, when the vein again opens, and at the present depth 2 feet, it measures at least 6 feet. Samples taken personally , and selected so as to present as fair an average as possible, by fire assay $16 per ton of 2,000 lb. of ore." Prof. Chap- s made under date of May 9th, 1893. Referring to the O'Neill ns that a trial pit 28 feet deep had been opened near its south- ty. "The vein consists of quartz and disseminated pyrites, ctically identical in character with the Main vein, although reater width. A fair sample of unoxidized ore taken from this fire assay $17 gold per ton of 2,000 lb. of ore. From its course Neill vein must cut the Main vein near or just beyond the dge ot the location." Of the Centre vein, he says that a small

10. Shafthouse and mill of Belmont mine.

zed earthy matter, mixed more or less with soil, taken from the nearly $5 per ton. "Although satisfactory as showing the of gold, this assay cannot be taken as an indication of the true , the ground at the spot being entirely unopened." In summing of the property, the value of which he affirms that he has not aggerate in any way, Prof. Chapman says: "It is undeniable the quartz veins upon the property, taking one ton with vorkable amounts of gold-bearing ore. But the great test after st; and the result of the milling operations at the Belmont verage yield of at least $10 per ton of stuff passed through the

Report of Ricketts and Banks of New York.

r of last year another report on this property was made by s and Banks, a well-known firm of mining engineers and metal- York city, the former of whom is Prof. Ricketts of Columbia

College. The report was made to the Moira Gold Mining Company of New York, which had acquired an option on the property. In describing the ore deposits they say: "These consist of a system of quartz veins more or less decomposed near the surface and carrying sulphurets of iron and copper in depth; traces of galena were also observed. Four distinct veins were noticeable, two with a general east and west trend and a southerly dip, and two with a northwest and southeast trend and a southwest dip. The veins are contained in and interstratified with chloritic schist. The foot wall is schistose and as a rule generally well defined, but the hanging wall is less strongly marked, more or less undulating, harder and gneissoid in character. The sulphurets are scattered through the quartz gangue of the veins with occasional strings and bands near the walls or line of junction of the quartz and interstratified chloritic schist. The chloritic schist is persistent throughout the entire course of these veins, and is plainly observable where crosscuts and openings have been made; also wherever the quartz outcrops on the surface." In describing the Main vein where the shaft has been sunk upon it they say: "The vein shows distinctly the entire depth of the shaft, a distance of about 132 feet. It has a west-northwest and east-southeast strike, and an almost vertical dip. The width of the vein at the surface is about 3½ feet, but on descending it widens to about 12 feet, pinching again to about 1½ feet. This pinch continues for some distance, say 25 feet, when the vein again widens to about 6 feet at or near the bottom of the shaft. A spur was noticed at a depth of about 50 feet coming in from the north. Near the surface, and in the upper part of the shaft, the ore was found to be more or less oxidized in character, but below this the vein matter is a hard white quartz containing sulphurets in variable quantities, and interstratified with schistose rock. At the time of inspection water was coming into the shaft in quantity from a crevice or split in the vein on the east-northeast side, near the bottom. The foot wall of the vein seemed to be quite regular, but the hanging wall was of a harder character and less well defined." Samples were taken at various points on the location by chipping across the vein exposures, and from the ore piles, and fifteen of these gave an average of $15.30 per ton. A sample of tailings from the Crawford mill was also tested and gave $3.51 per ton. This shows a high percentage of loss. But the most reliable result was obtained from a mill test of 12 tons of ore treated in the Crawford Improved mill, the clean-up of which was made at the time of the inspection. This gave a total of $75.12 gold from the amalgam and $29.83 from the concentrates, with a loss of $14.88 in the tailings, or an average content of $9.98½ per ton. "The tailings from this test and from the previous runs made at the mine showed on panning much floured 'quick' and sulphurets; also some free gold."

Tests of the ore by assays and mill work.

My own visit to the Belmont mine was made on November 18, in the company of Mr. Carscallen; but the works had then been closed down for some time and the main shaft and nearly all the other openings were filled with water. I have therefore drawn upon the reports of Prof. Chapman and Messrs. Ricketts and Banks, who saw the works in progress, as furnishing a trustworthy account of the veins shown by the workings, as well as the

quality of the ores. Both reports concur in the opinion that
rue lodes, that the cost of mining and milling the ore should
per ton, and that an average yield of $10 per ton should realize

g the location to the Moira Gold Mining Company, all members
dicate except Mr. Carscallen parted with their interest in it;
et certain that the deal will be carried through.

THE LEDYARD MINE.

The Ledyard location in Belmont.

Magnetic iron ore explored.

Discovery of a gold-bearing vein.

Character and quality of the ore.

Testing the value of the ore.

rd mine adjoins the Belmont on the south, being upon the east
in the first concession of Belmont. There is an important out-
agnetic iron ore in the northern portion of the lot, which has
a company of New York capitalists. Exploration by borings
satisfied the company that there was a large body of iron ore,
ty, and a railway track has been graded from the line of the
rio Railway near its junction with the Canadian Pacific to the
In exploring the southern portion of his lot Mr. Ledyard dis-
artz vein which upon examination was found to be auriferous,
ples were rich in visible gold. The formation is diorite, and
anges cross the property in a northeast and southwest course for
about 300 yards, rising to a height of 25 or 30 feet. These
rite are cut by two or more veins of quartz having an east and
and in the bluff of the eastern range one of the veins outcrops,
o lie between selvages of talcose schist and to dip southward at
5°. About 30 yards west of this bluff a shaft of 8 by 12 feet
upon the vein to a depth of 45 feet. The vein varies in width
six feet, and shows free gold to 25 feet. At the bottom of the shaft
by a horse, so that the walls are 12 feet apart. It is largely com-
ite cellular quartz with iron and copper pyrites in cavities, showing
e decomposition products having leached out largely; but a por-
uartz is stained with iron, holding iron pyrites decomposed in
onite. Some specimens are very pretty and rich. At the south-
e westerly range, called the Burnt Knoll, there is a large over-
z, and pits sunk upon it indicate the presence of two veins cross-
er below. The Burnt Knoll is 150 yards west of the shaft, and
y cut by the same vein. Numerous assays have been made of
this property, nearly all of which show it to be rich; but it is
o compute the value of a gold mine from the data of samples.
f iron pyrites and quartz assayed by Elliot and Chambers of
e an average of $326 per ton, and three lots of crystals of pyrites
urnt Knoll gave an average of $90 per ton. One lot from the
t half a shot bag full of small pieces of ore from all over the ore
g no visible gold," was assayed at the Orford Copper Company's
nstable Hook, N. J., and gave 4.7 oz. or $94 per ton. Another
, mostly from the Burnt Knoll, and described as consisting of "a

white, sub-translucent, rust-stained quartz carrying a somewhat large quantity of iron pyrites," was assayed by Dr. Hoffman of the Geological Survey, and shown to contain gold at the rate of 4.608 oz. per ton. A mill test of three tons made by Ricketts and Banks of New York produced $25.40 per ton, being 92 per cent. of the assay value.

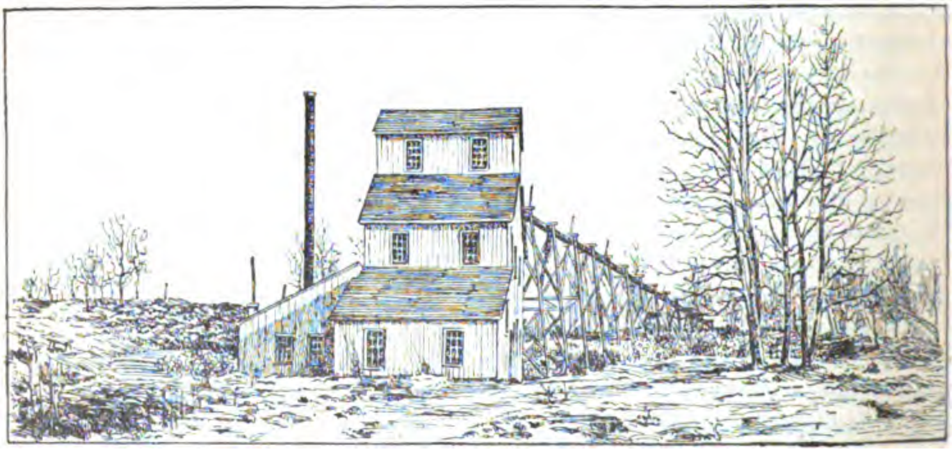
Exploratory work.

Exploratory work on the Ledyard mine was commenced in May of last year under the management of William Nichol, and when I visited it on 18th November nine men were employed. Mr. Ledyard has organized a company to carry on operations, and it is proposed to treat the ore with a Huntington mill.

THE CRESCENT MINE.

Reworking an old property at Malone.

The Crescent gold mine is on lots 16 and 17 in the eleventh concession of Marmora, near the hamlet of Malone. Portions of the property were worked during the period of gold excitement in Hastings over a quarter of a century ago; but though good shows of gold were obtained near the surface, the veins were not found to be continuous. The Crescent Company was organized in Montreal two or three years ago, and having acquired a right to work one of the old mines at Malone they proceeded to erect a stamp mill and to explore the several outcroppings for gold-bearing ore. The main building of the mill is a substantial frame structure 67 by 26½ feet and three stories high, with an engine room attached of 48½ by 21 feet. A boiler of 90 h.-p. supplies the motive power. The mining machinery was furnished by Fraser and Chalmers of Chicago, and consists of a ten-stamp mill with Frue vanners, a Blake crusher, grizzly and self-feeders. The stamps have a drop of 6 to 7 inches, and strike 70 per minute. While in operation at intervals in 1892 and 1893 about 1,200 tons of ore was crushed, yielding 245 oz. of gold, or an average of about $4 per ton.



11. Crescent gold mill, near Malone.

A ten-stamp mill erected.

There are several veins on the property, having a north and south course and dipping west about 75°. Mispickel occurs in places in the veins, but they are composed mostly of free-milling quartz. Many pits have been sunk, and there are two shafts, one of which has a depth of 90 feet. In the latter the vein is believed to have pinched out, but the mining work at first was very unskilfully directed and there is no certainty that the ore may not be continuous. It is very doubtful however if it is to be had in paying quantity. The country rock is composed of granite and calc schist, and is very rough and broken.

Mining operations.

THE PEARCE MINE.

A mispickel vein in Marmora, worked to supply the new reduction mill.

The Pearce location is composed of 22 acres on lot 8 in the eighth concession of Marmora. The vein has an east and west course through a granitic formation on the east side of the Moira river, and at the surface is only one foot wide. An option upon it was secured by the Hastings Mining and Reduction Company, and early last year work was commenced upon it. This was discontinued in spring owing to high water in the river, and was not resumed until August. In November the shaft of 7 by 9 feet had reached a depth of 90 feet, and at 42 feet a level had been driven eastward 27 feet. At this point the vein widens to 3 feet 8 inches, but at the bottom of the shaft it narrows to 18 inches. At the surface it has a dip of 30° southward, which at 40 feet increases to 40°. Over 300 tons of mispickel ore had been taken out up to the middle of November with a force of seven men, which was treated at the Company's mill in Marmora. The average yield was about $8 per ton, representing 85 to 90 per cent. of the assay value. It is understood that owing to financial disability the Company was unable to complete its purchase when the option expired at the end of the year, and that the property has reverted to Mr. Pearce.

A PIONEER EXPLORER IN HASTINGS.

Marcus Herbert Powell, of Marmora,

One of the earliest explorers for gold in the County of Hastings is Marcus Herbert Powell, clerk of the Division Court at Marmora. Although but little more than fifty years of age, he has the honor of being the discoverer of the Richardson mine in the township of Madoc, which was an exciting event in that region twenty-eight years ago. Mr. Powell retains his interest in prospecting work, and occasionally spends a few days in going over his old hunting ground. Four years ago he discovered gold on lot 24 in the fifth concession of Marmora, which is now known as the Demars mine. It is an arsenical ore, he says, cropping out over a width of 66 feet in a mixed country rock of quartzite and granite. "The ledge has been traced by me for 12 miles from Belmont, through Marmora, and I think it strikes the corner of Tudor." I was unable to see this property, but Mr. Powell shows very fine samples of free gold ore which have been taken from it. Two or three test pits have been sunk, but no actual mining work has yet been attempted.

discovers the Demars location.

THE RICHARDSON MINE.

His story of the discovery of the Richardson mine, and of

The following account of the discovery of the Richardson mine was given me by Mr. Powell, who is an intelligent but unassuming man. It is worthy of being put on record as perhaps the only narrative of the event ever given by the discoverer himself for publication. "I began prospecting in Madoc," Mr. Powell said, "in the spring of 1863, and explored Belmont, Elzevir and other townships in search of copper, having for associate a German copper miner named Nicholas Snider. He continued with me for two years and a half, but nothing of value was discovered and we separated. I kept on, taking with me as my new associate one William Berryman. On 15th August, 1866, I discovered gold on the John Richardson lot, the east half of 18 in the fifth concession of Madoc, containing 100 acres. I was following on a seam for copper, and at a depth of 15 feet I struck ore carrying free gold. The seam was six inches wide at the top and was decomposed for six feet; then it was solid rock to 15 feet, where it suddenly opened out into a cave 12 feet long, 6 feet wide and 6 feet high, so that I could stand upright in it. The hanging wall was quartzite and the foot wall granite, while the roof was composed of spar, talc and rocks of various kinds, and the floor of iron, talc, quartzite, black mica and other minerals. The gold was found in all these rocks in the forms of leaves and nuggets, and in the roof it ran through a foot thickness like knife blades. The largest nugget was about the size of a butternut. This was the first discovery of gold in the district. We sold the property to Lombard and Hardin of Chicago for $36,000. I don't know how much gold was taken out; but I guess the miners got as much as the owners, for I have seen specimens of it all over the country. I remember very well the raid made upon this mine in the summer of 1867, under the leadership of 'Caribou' Cameron. I suppose there were a hundred men with him. The reason of the raid was, that they did not believe there was any gold in the mine. Ropes were thrown over the shaft house to pull it down —Hardin being in charge at the time as superintendent—but before any damage was done 'Caribou' Cameron and another man were allowed to enter the mine and examine it. By this time two or three men of the Mounted Police had come up from Madoc, six miles off, and the raiders quietly dispersed.[8] Mining was continued until the spring of 1868; but although explora-

the raid under 'Caribou Cameron.

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[8] The following report by Alfred A. Campbell, Inspector for the Madoc Mining Division, made to the Commissioner of Crown Lands under date of May 6, 1867, gives some interesting particulars of the Richardson mine and the attack made upon it, as well as of the general state of gold mining in the district. It will be noticed that he fixes the occurrence of the raid on the Richardson mine more definitely than Mr. Powell, and at an earlier date:

"I have the honor to report for the information of the Honorable the Commissioner of Crown Lands that I have just returned from a tour through the gold region of Madoc; that I find, owing to the very unfavorable state of the weather, it having rained incessantly for the past three weeks, miners have been unable to continue work, the surface water filling up most of the excavations; and in my opinion nothing much can be done for the next three weeks. There have been however about one hundred shafts sunk in Madoc and adjoining townships, and every preparation is being made to continue the work as soon as the weather will permit.

"Prospecting is going on to a large extent, there having been no less than from three to four thousand strangers who have visited Madoc during the last month, a large proportion of whom remain to prospect. Gold has been found to some extent on lot 29 in con. 4 of Madoc, at Downie's Rapids in Hungerford, and also in Tudor, but whether in paying quantities remains to be seen.

"There are at present four four-horse coaches and two covered stages, besides numerous private conveyances, leave Belleville for Madoc daily; also line from Brighton by way of Trenton and Stirling to Madoc. A daily express has also been established. The work of erecting a telegraph [line] is also being rapidly pushed forward.

"At El Dorado, where last fall there was only one solitary log shanty, there have been already erected some eighty buildings, with many more going up; in Madoc some eighteen new buildings are also being erected. Messrs. Gilbert and Turley are importing a steam tion work has been undertaken at various times since, no gold has been found. There were 19 acres in the location, which I had under lease from Richardson for a consideration of one-half of the mineral won. In dividing the proceeds of the sale to Lombard and Hardin, Richardson got $21,000 and Berryman $1,500. I gave my old associate Snider $3,500, and had $10,000 left for my own share."

THE MARMORA GOLD MILL.

Early gold mining in Hastings.

It is now more than a quarter of a century since gold was discovered in the county of Hastings. For several years mines were worked at various points in the townships of Marmora and Madoc, and a number of mines gave good promise to their owners. Several mills for treating the ores were built, and excitement at times was raised to a fever heat as new discoveries were made. But in almost every case it was found that when a shaft had been sunk to the water-line the ore ceased to be free milling, and no process then known made the economic treatment of it possible. The mispickel, although still rich in gold as shown by assays, was too refractory to yield the precious metal in paying quantities; and notwithstanding that various methods were tried and large sums were wasted on new experiments, conviction slowly settled down on the minds of capitalists, miners and metallurgists alike that there was no money to be made in mining or milling the mispickel ores of Hastings. But the disaster which a short time ago overtook silver mining has led to a re-awakening of interest in gold mining, and once more attention has been directed to the old Hastings field and to improved methods of treating its mispickel ores,—for the genius of the inventor has not been dismayed by the failure of former methods. The most successful of these has been put to the proof of a mill test for the first time in the village of Marmora, and the results it has given are such as to merit a detailed description.

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quartz crushing machine, to be put up either at El Dorado or Bannockburn, which they expect to have in active operation in the course of a fortnight or three weeks.

"I have issued some thirty mining licenses, and as soon as the weather will permit the whole country will be thoroughly explored, when I hope to be able to report more fully and satisfactorily that gold exists in paying quantities in localities other than the Richardson mine. This latter promises to be one of the richest mines as yet discovered in any country. Messrs. Lombard and Hardin commenced operations at the mine on Friday the 26th ultimo, but on Wednesday were served with an order from the Court of Chancery, in consequence of which they have suspended all further work.

"I have also to report an unlawful organized attempt on the part of some one hundred miners and others to effect an entrance into the Richardson mine at present in possession of Messrs. Lombard and Hardin, not for the purpose of plunder but merely to satisfy themselves that gold existed in paying quantities, and that the whole affair was not a humbug. Two of the party were allowed to examine the mine, and were quite satisfied with the result. This sort of organized intimidation is much to be regretted, as it may lead others less scrupulous to follow the same precedence, and may lead to acts of injustice and robbery; happily however in this instance, owing entirely to the good sense of Mr. Hardin, bloodshed has been averted and quiet restored. The police were sent for and they together with myself were promptly on the spot; their services however were not required, as matters had been amicably arranged before their arrival. I have however thought it prudent to station a force at El Dorado. This I think has proved the necessity that exists for the organized police force which has been established for this Division."

Referring to the police force, the Report of the Commissioner of Crown Lands (Hon. Alexander Campbell, the late Sir Alexander) for 1867 says: "As it was anticipated that a large number of persons would resort to the district for the purpose of prospecting and working for gold, a considerable number of whom would probably be men of violent character and habits, it was deemed necessary for the maintenance of order and the rights of property that a police force should be placed at the disposal of the Gold Mining Inspector, and a troop of twenty-five mounted police was organized under the authority of an Order in Council of the 22nd March, 1867. They were discharged on the 30th September, 1867."

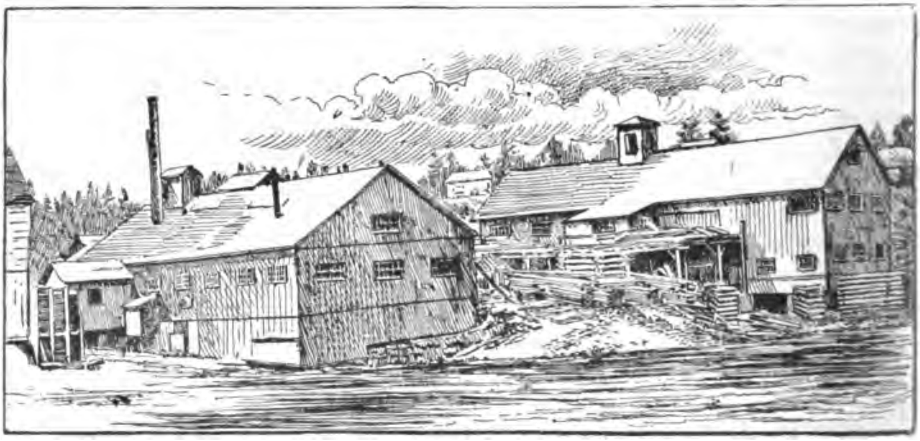
THE WALKER-CARTER PROCESS TESTED.

Testing the Walker-Carter process upon mispickel ore.

The original inventor of the Walker-Carter process for treating refractory gold ores is an American named Bancroft, who is said to have spent fifteen years in perfecting it. Patents were taken out in the United States and Canada, the holders of which are Messrs. Walker and Carter of Philadelphia. Through Mr. Arthur Kitson of that city it was made known to Mr. Alexander Keith of Toronto, and by him to Mr. F. B. Allan of the same city. After some negotiations Messrs. Keith, Allan, Kitson and John Scott of Philadelphia acquired the right to use the patent in Canada, and in 1892 the Hastings Mining and Reduction Company was organized to test the utility of the invention on a business scale; as hitherto its success had only been demonstrated in the laboratory.

The mill at Marmora.

A site and waterpower privilege on Crow river in Marmora were secured from Mr. T. P. Pearce, and a mill was erected on a small granite island in the river, just below the dam. The northern portion of the mill rests on solid rock, while the southern end is supported by cribwork. It is a frame structure of one story, and as first planned was 40 feet by 70; but an addition of 24 feet has been made to the length to provide accommodation for a subliming furnace to refine arsenic, so that the building is now 40 feet by 94. Work upon it was commenced in November, 1892, and the first run was made in April, 1893, but owing to high water steady work did not begin until June. From that time to the end of the year it ran continuously night and day, saving a few days when it was closed down for additional improvements or slight repairs, or for want of ore supplies.



12. Marmora gold mill to the left; sawmill to the right.

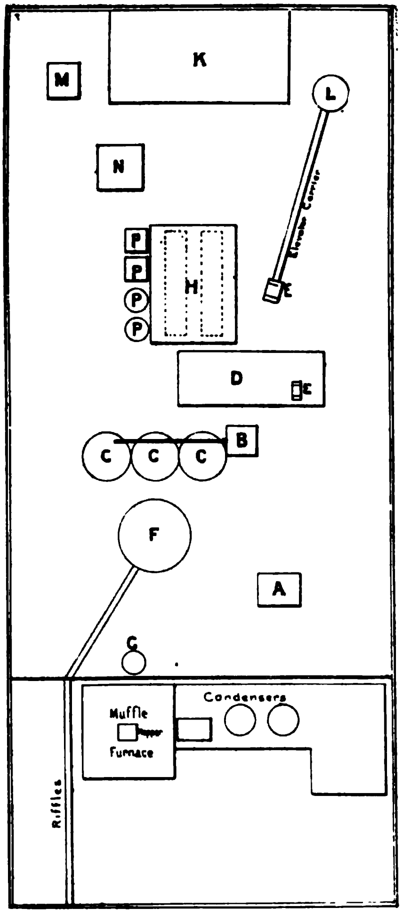
First stage in the process—Crushing and grinding the ore.

In the process of treating the mispickel ore the first step is to run it through a Blake crusher, in which it is broken to the size of nut coal. As delivered from the crusher it is spread over a drying floor or platform of cast iron plates, resting on brickwork and heated by flues underneath. This floor is 9¾ feet by 18¾, equal to an area of 183 square feet, and the ore may be spread over it to a depth of six inches. When sufficiently dried, which requires only a few hours, the ore is fed into a Griffin mill and reduced to the fineness of flour (or say a 50-mesh screen) at the rate of 7 to 8 tons per day. Thence it is conveyed through a tube by the action of a screw rake to an elevator and lifted to a hopper of 10 tons capacity under the roof of the mill, 24 feet above the ground floor. From this hopper the ore descends through an automatic feed-valve to a muffle furnace, where it is roasted to drive off the arsenic and sulphur and liberate the gold.

Second stage in the process—

Treating the ore in retorts to eliminate arsenic and sulphur.

The roasting furnace stands near the centre of the main room of the mill. Its walls are built of brick, upon a stone foundation, and are 8¾ feet wide by 12⅓ long and 12 high, lined inside with firebrick. Its ends are iron plates 6¾ feet wide by 9½ high. The fire chamber holds two sets of retorts for roasting the ore, each set composed of four sections with end connections, and built one under another in such a way that the ore at no point in its downward progress through them comes into contact with the flame or smoke. The two uppermost sections of the retorts, which receive the charge of ore cold from the hopper, are made of half-inch iron, with internal diameter of 16 inches and length of 9 feet. The others, which are subject to a stronger heat, are built of fireclay, having a shell of three inches thickness. They are ellipse-shaped, with internal diameters of 16 and 21 inches and length of 9 feet. From centre to centre of the sections is vertically 2¼ feet and horizontally 2½ feet, thus leaving an intervening space of three to five inches for their full length through which the smoke and heat rise from the fire box to the chim-



13. GROUND PLAN OF THE MARMORA MILL.

A. Mercury retort.
B. Amalgamator.
C. Collecting pans.
D. Cooling floor.
E. Elevators.
F. Settling pan.
G. Clean-up pan.
H. Roasting furnace.
K. Drying furnace for ore.
L. Griffin mill.
M. Blake Crusher.
N. Chimney shaft.
P. Arsenic chambers.

ney shaft. Each section of a retort is equipped with a rake, the teeth of which are arranged spirally on a shaft of gas pipe to move the charge of ore from one end to the other in the operation of roasting. The termini of the shaft rest in the end-plates of the furnace, and it is driven by a wheel and its toggle-jointed arm so as to move the rake to and fro within an arc of 120°,—the same motion being conveyed simultaneously to the rakes in all sections of the retorts. To protect the rakes from the heat of the furnace they have been given four coats of asbestos cement, each coat followed by a wrapping of fine wire to prevent scaling, while by hose connections a continuous flow of cold water is kept up through the shafts. Pine slabs from a neighboring sawmill furnish the fuel of the furnace, and are well adapted for the purpose by the flames and heat they yield.

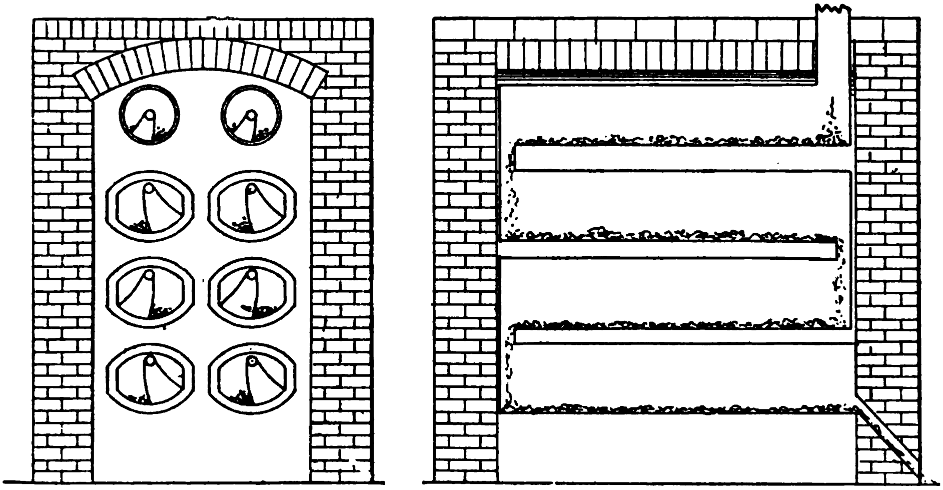
The operation of the retorts.

When the plant is in operation the ore is fed in fixed and regular quantities into the uppermost sections of the retorts, at the ends opposite the fire box, and is carried forward by the regular movement of the rakes to fall through slides at the other side into the second pair of sections, and so on into the third and fourth sections, to be finally discharged after traversing a length of 36 feet into a cooling bin on the floor. During its progress the charge continues to be stirred by the action of the rakes, so that every particle is uniformly heated, and as the temperature increases in each successive section the highest roasting capacity of the furnace would appear to be attained. But the thoroughness of the process will depend on conditions. The ore may not be ground to the proper fineness, or the feed-valves may deliver in too large quantities, or the charge may be driven too fast, or the furnace may be maintained at too low a temperature. What is required is the application of enough heat to break up the affinities of the arsenic, sulphur and iron in the whole charge before it reaches the vent, and a knowledge of proper conditions can only be gained by experience. But the Walker-Carter plant has the merit of being readily controlled when what is required is rightly understood, and once it is got into running order the only matter that demands human labor and intelligence is supplying fuel to the furnace; all the rest goes on automatically. The ore is ground to a certain fineness, it is fed into the retorts in definite quantity and makes uniform progress through them, and if an even and sufficient temperature is kept up the oxidizing of the charge will be complete. The iron, gold and earthy material of the ore are deposited in the cooling bin, and the arsenic and sulphur ascend in fumes through the retorts to be held and condensed in outside chambers if provision is made therefor, or otherwise to escape into the air. At the Marmora mill the arsenic only is saved.

Third stage in the process—

The amalga

In the state in which the ore comes from the furnace the gold may be separated from it by the old and simple operation of panning; but the Walker-Carter process includes an amalgamator of ingenious device which as nearly as possible makes the treatment exactly mechanical and automatic. Simply stated it consists of four parts, viz.: (1) Iron hoppers with feed-valves for ore and mercury; (2) Upright iron tube to receive charge; (3) Brick furnace enclosing upright tube; and (4) Water-jacketed horizontal pipe to discharge into collecting vats. The furnace is a brick chamber 3 feet 2 inches square and 9 feet high, with a fire-grate at the base and flues rising to six inches of the top, which is covered over. Built into this chamber and resting on supports 3½ feet from its base is the upright iron tube, which is 9½ feet high, and 10 inches diameter. A section of 5 feet of it is exposed to the heat of the furnace, and about 4 feet is unenclosed, connecting at the top with a chute from the ore and mercury hoppers. Near the bottom of the upright tube, which is bulb-shaped, is an intercepting pipe in horizontal position which extends outward over the collecting vats. It is about 5 inches diameter, has a length of 12 feet, is water-jacketed two-thirds of its length, and discharges at the outer end by means of a revolving screw rake. The iron hoppers are on a floor over the cooling bin, a small one to hold mercury attached to the side of a much larger one to hold roasted ore. The bottom of the smaller hopper is an axle that in motion revolves at a rate of seven per minute, driven by cogged gearing. A hole of one-quarter inch diameter bored in the axle allows a measure of mercury to drop through with each half revolution, to mix with a measure of ore dropped at the same time from the feed-valve of the larger hopper and fall through a short chute into the upright tube.


14. Transverse and longitudinal sections of the Marmora Mill furnace.

After the roasted ore has cooled sufficiently in the cooling bin on the ground floor, it is lifted by elevators to a storage hopper of two tons capacity, from which it is delivered as required to the iron hopper below it. Thence it is fed by measured quantities into the upright tube over the furnace, receiving in the passage, as has been explained, the necessary proportion of mercury. No change takes place in the upper portion of the upright tube, but when the section within the furnace is reached the mercury becomes volatilized by heat and permeates the whole body. It cannot ascend in the tube, for the cold ore which is steadily coming down from the ore hopper would at once recondense it; but as it descends and the heat of the furnace increases it is subtilized to a very high degree, and in that state comes into contact with every particle of the mass. The most perfect diffusion is of course in the bulb, where it is nearest the fire. There is no amalgamation up to this point, but everything is ready for it, and as the burthen is conveyed

and its work.

The alloying of mercury and gold.

out into the cooling water-jacketed section of the discharge pipe in the arms of the revolving rake, we are to conceive a scene of amazing activity. It is not a case of seven women taking hold of one man; the infinitesimal atoms of the vapor of mercury seize upon the nearest dust or grain of free gold in countless numbers, increasing as the temperature falls, and by the time the point of exit is reached there is possibly not an atom of gold in the charge that is not in the embrace of many atoms of mercury. While the panning of roasted ore at the cooling bin will show many colors, samples taken as it discharges into the collecting vats exhibit many globules of amalgam, most of them no larger than pin points, but rarely if ever a color of gold. It does not follow however that all the mercury fed into the amalgamator alloys with gold. That depends upon whether there is much, little or any gold in the ore charge, and how evenly it is distributed through it. The volatilized mercury must recondense as soon as the proper degree of coldness is attained—gold or no gold within reach of its affinity.

Fourth stage in the process—

Three collecting vats (5 feet diameter and 3 feet deep) arranged on a sloping floor under the discharge pipe and a large settling tank (8 feet diameter and 3 deep) on a lower level are provided to catch the amalgam. A steady stream of lukewarm water flows from the highest to the lowest, carrying along with it the treated ore mass, worked up into slime by revolving wings in the vats. Silver plates on the wings and copper plates on wall sections of the vats take up the amalgam, and should any particles float over they are saved in the settling pan. This operation is very carefully watched, as it always must be with any system of gold-milling where plates are used. But the loss of quicksilver is very small. At first it was half an ounce for every ton of ore put through the amalgamator, but this rate was reduced as experience was gained. In one run of the mill in which 498½ lb. of quicksilver was used, 496½ lb. was recovered, or an average of 99.6 per cent.

Collecting the amalgam.

The tailings from the settling tank are carried by a discharge spout over iron riffles a length of 36 feet to the river at the farther end of the mill; but it has not been found that anything of value has been saved on them, except a very small quantity of floured mercury.

Collecting and refining the arsenic.

In saving the arsenic the fumes from the retorts are let into a series of dust and cooling chambers where it condenses in the form of gray arsenic, and further treatment is required to refine it. For this purpose a subliming furnace has been erected in the smaller room of the mill. It consists of a muffle furnace and two iron condensers, and the operation produces a white arsenic of fine quality.[9]

Claims made for the process as evidenced by the Marmora mill test.

This mill test of the Walker-Carter process proves, it is claimed, that 90 to 95 per cent. of the gold in mispickel ore is saved, that almost all the mercury used for amalgamation has been recovered, and that the work can be

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[9] As showing the English method of collecting and refining arsenic at one operation, the following extract from an article on Arsenic Mining on the Tamar is quoted from Industries and Iron for November 24, 1893:

"The famous mine known as the Devon Great Consols is the principal source of arsenic in England. Early in this century the mountainous spurs flanking the Tamar attracted the attention of mining speculators. We have the authority of the Rev. S. Baring-Gould for the statement that, in spite of large expenditure, no result accrued until in 1844 a fresh attempt on the part of a new company was made with success, as nine feet below the point at which the mine had been abandoned a very rich lode of copper ore, thirty feet wide and one

profit with ore yielding $8 of gold per ton.[10] With arsenic and
o saved as by-products, it would appear that the process has
lem of treating auriferous mispickel. But the strange part of
hat the owners of mispickel gold mines in the Marmora dis-
w any desire to further the enterprise by working their mines
re to the mill. If not wholly misrepresented, their chief aim
sell their properties for a large sum of money, and leave to
he risk and the business of opening and working them.
ra plant is small, because it is experimental; but if it does
may be erected of any desired capacity. It has been run
for about six months with five men, three on the day and two
ift; and it is but fair to say that for the success attained the
due to the skill, intelligence and judgment of the president of
Ir. F. B. Allan, and its superintendent, Mr. W. H. Wylie.

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s struck. So successful did the operations prove that at the end of ten
ny divided £70,000. The lode was worked for twenty-eight years, and
hough it would have been abandoned before this had not the waste thrown
hen copper was sought proved rich in arsenic. The Devon Great Consols
o arsenic works. Copper is still raised, but in a comparatively small
patched to South Wales, there to be smelted. As it takes four tons of
on of copper, it is obviously advisable to carry the ore to the coals and not
the ore. Besides copper ore, the mine had yielded vast quantities of
rites. The arsenical pyrites consists of 25 to 30 per cent. of iron, 12½ to 14
ic and the rest earthy matter. This goes through several crushing and
the latter being carried on by girls from thirteen to sixteen years of age.
d jigging—that is, sifting—the arsenical pyrites is conveyed to the first
is burnt with low class coal and produces 'arsenic soot'—that is, arsenic
oke-soot from the coal as to be of a gray colour. The arsenic and soot
ined in the chimney, or condenser. This is scraped out and taken to the
be purified. These calciners consist of revolving iron drums through
hracite coal is carried on rotating iron furnaces kept red-hot to which the
d, the arsenic being sublimed and condensed. The calcining of the arsenic
rkmen. Three men in four weeks will make 100 tons of arsenic; if they
ceive extra premium; if they burn the arsenic badly, so that it is wasted,
the fine has been known to amount to 30s. Some years ago arsenic soot
d. to 15s. a ton; it is now worth from £7 to £7 10s. The chimney in
is condensed is a mile long, carried on an incline up the hill, with iron
As the hot blast passes up the chimney, it deposits a crust of arsenic
ck work all round to a depth of from two to three inches, and it deposits
stals on the floor. Before the smoke passes into the upright chimney, the
125 feet, it has to traverse a shower of water, which catches what remains
hing but sulphurous acid being allowed to escape. The crystals of arsenic
the flue or condenser whilst still warm, and are ground in a mill to flour of
h it is packed in small barrels containing a little over three cwt. The men
enic, either raking up the arsenic soot or scraping out the condensers or
mill, are obliged to wear mufflers over their mouths and noses to prevent
articles. The arsenic workers are obliged to wash themselves thoroughly
rning from work, as the arsenic is liable to produce sores if permitted to
or folds of the flesh, or about the mouth and nostrils. As a rule it only
worker is careless about his or her personal cleanliness. Otherwise the
t prevents all eczema; and the fumes of sulphurous acids, as well as the
fatal to the germs of disease. Eventually the workmen may come to suffer
ical poisoning, indicated by loss of appetite, nausea, frontal headache and
his is the case they have to give up the work entirely, but many remain at
eat many years without any suffering. The vapor of the burning pyrites
rsenic, but sulphur as well, the iron cinder is cast away, the arsenic is con-
ne the upright shaft is reached the vapor is reduced almost entirely to
The water flowing away from the chimney is like soapy water, so charged
, and the fume blasts the vegetation for some distance round, making
eyesore in the landscape. When the upright shaft has to be entered for
fect on the eyes is most painful. The men wear linen garments lined with
lphuric acid fumes completely destroy the linen in a few moments, leaving
so that the men go into the shaft in linen and come out clad in wool.
cessity for entering the shaft is not of frequent occurrence, or great loss of
"

age of gold lost by the process depends on the roasting. If the arsenic
t wholly driven off, the gold contained in them will not be recovered; and
ll probably be found in the most carefully roasted ore.

III.

COPPER AT POINT MAMAINSE.

David Thompson's description of Lake Superior.

"The River St. Lawrence is too well known to need any description from me. I shall confine myself to remarks on the great Lakes, of which it is the drain. Lake Superior may be said to be it's head water; this Lake lies in a deep hollow of the west part of the stoney region, it is every where surrounded by rocky hills, it's northern side rises on an average 850 feet above the Lake, in places much higher, the east side is much the same; almost all of different shades of granitic rock: it's heights are not many miles from the Lake, full of Ponds and Brooks, among moss and Forests of small woods of Pines, Birch and Aspin. The whole is a poor country not fit for cultivation. The south side is still higher, but the heights at many miles from the Lake. The sides of the Lake are mostly of sand or lime stone. The land on the south is much better than on the north side; but not very promising for cultivation. On the north side the Lake receives 30 Rivers from 20 to 100 yards in width, three of which, the St. Louis River at the south west end of the Lake, the Neepego near the middle and the Mishipacoton in the north east corner of the Lake are considerable Streams, and 28 Brooks all of them with many Rapids, Falls and carrying places. On the south side are forty Rivers from 20 yards wide and upwards. Two are 120 yards in width with 41 Brooks, all of them have many Rapids and Falls, but have more water than those on the north side. The evaporation from this great Lake seems confined within it's hills, is condensed before it can ascend above the hills, and returned to the Lake from frequent rains in numerous streams. It is sometimes agitated without any apparent cause. As I was surveying this Lake in 1822, the day was fine and calm (July) about 50 miles from the south west end of the Lake, at noon, the Lake became much agitated, and the waves rolled on the shore as in a breeze of wind; I had to stop for about three hours. On looking at the Lake, about two miles from me, I saw a space of about 300 yards filled with a dark mist which came from the depths below in a rude column of about twenty feet in height, from whence it extended itself horizontally and was lost. As soon as this ceased the waves subsided, and I proceeded on my journey. Lake Superior lies between Latitude 46.27 N. and 48.58 N., and Longitude 84.15 W. and 92.16 W., its greatest length is 386 miles, it's breadth 179 miles; it's circuit is 1617 miles, it's area exclusive of Islands 25,057 miles, it's level above the sea 625 feet. In the north east quarter there is much basalt; Pye Island is wholly of it; close to this Island the Lake has been sounded with 350 fathoms of line, no bottom; on the north side is Thunder Point, of Basalt, it rises perpendicular from the Lake 1120 feet, a great part in appearance is of a fluted form. Here also a line of 350 fathoms

Extent of the lake.

found no bottom; hence this Point of Basalt must be at least 3225 in height from the bottom. Here then we have a certainty that the bottom of the Lake is at least 1475 feet below the surface of the sea, but it is very probable that parts of the Lake are 600 fathoms in depth, if so, the bottom is 3000 feet below the surface of the Ocean. At the average depth of 200 fathoms, a low average, this Lake contains about 6000 cubic miles of fresh water. In the severest winters, only it's Bays are frozen over, which every gale of wind breaks up, and causes much floating ice. When in 1798 as I was surveying this Lake I went up the Ontonoggan River (by the U. States called the Eagle River) to a mass of native copper, but with my small axe I could not get a piece of it. It lay below a cliff on the lime stone shore of the River, and was much rounded by water. I have lately been informed that it weighs 3000 lbs., and has been taken to Washington at the expense of 5000 dollars. The same year on the survey, about 52 miles northward of the Falls of St. Maries, near Mahmaize, there were five, or six canoes of Indians, who informed me they were then at the old path of their grandfathers, who used to come here for pure copper for heads to their Lances, arrows, axes, knives, and other necessaries; by their description the place was about five miles in the interior. I requested to be shown the place, but they said they did not exactly know it, and dreaded the Musquitoes. It appears that in those days, the first settlement of this country, the ornaments of the Churches of Rome came from these two mines, in pieces of pure copper. In the survey of 1822 at the north east end of the great Point, now called Keewenaw, I found a small secure harbor, from which I took specimens of copper ore, which I named Copperas Harbor. This place has since been worked with profit, as has also a considerable tract of country by the people of the United States, who by treaty have about three-fourths of this great Lake by Lord Ashburton's capitulation. On the British side eastward of Thunder Point towards Mishipacoton River, there is an Archipelago of Islands, lying from west to east, of about 100 miles in length, in this direction; for these two years past (1845-46) they have been closely examined, and the greatest part of this Archipelago of Islands are found to be rich in copper ore, as also parts of the main shore. Companies are now formed to work these extensive copper mines, with what success is yet to be known; but let us hope that several ships may be loaded with rich copper ore for the ports of England. There are scarcely any hopes this Lake will ever be examined by scientific Men. They have too many hardships to encounter; they must carry their Provisions with them, live in tents exposed to the Rains and Storms of the Lake, and the worst of all, myriads of Musquitoes. Hopes of profit may cause localities to be explored, but that is all."

Copper on the south and east shores.

A visit to Mamainse in 1798.

Copper on the north shore.

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[1] David Thompson's Journals and Surveys in the Crown Lands Department, Appendix pp. 7-10. The extract given above is a literal transcription from the MS. The Journals and Surveys are recorded in thirty-eight books. Thompson's spelling of Mamainse accords very nearly with the modern pronunciation. In Keating's Narrative of an Expedition to the Source of St. Peter's River (1823) it is called Point de Memens, described by him as "a corruption of the Indian word Marmoaze, which signifies an assemblage of rocks." Keating further says: "We there met with trap rock in place, but the beach is strewed with water-worn fragments of conglomerates or sandstones." Vol. II, p. 196. Dawson's spelling of the word in 1857 was "Maimanse"; while on the Geological Survey map of 1863, and more recently by Dr. Robert Bell, the word is "Namainse" (Little Sturgeon). Geo. Sur. Report 1876-7, p. 213.

EXPLORATION WORK OF THE MONTREAL MINING CO.

The existence of copper on the south shore of Lake Superior was known to Jesuit missionaries and others two centuries ago, but Mr. Thompson appears to have been the first white man to learn of native copper being found on the east shore of the lake. Ten or twelve years after the Appendix to his Journals was written the Montreal Mining Company acquired two extensive locations on the Point by purchase from the Crown, and began to explore them for copper and other minerals. The results of operations there are recorded in the twelfth Annual Report of the Directors, under date of 17th February, 1858, for a copy of which I am indebted to their old manager, Mr. E. B. Borron, now of Toronto.[2] In his report to President Cross of the Company, under date of 31st December, 1857, Mr. Borron gave the following account of the exploratory work carried on at Point Mamainse:

Locations taken up on the Mamainse headland by the Montreal Mining Company.

BORRON'S REPORT ON PROSPECTING OPERATIONS.

Sanguine expectations not realized,

"The operations on this Location have not realized the sanguine expections so generally entertained in reference to it.

The surface show of Native Copper, of Grey and Yellow Ores of Copper, Lead Ore and Silver was such as to warrant a well grounded belief that some of these valuable Metals (but particularly Copper) existed in large quantity somewhere in the vicinity.

In the course of our search many Lodes have been discovered, even on that limited portion of the Location which can alone be said to have been at all explored. The tract in question is situated at the North West corner of the Location, and embraced about one mile in front and a mile and a half in depth, or little more than one-seventh part of the whole.

As we recede from the Lake Shore the ranges of Trap Rock are covered with a considerable depth of soil, which effectually conceals from view all traces of the Lodes which traverse such ranges. There is nothing for it but costeaning or uncovering the rock, by means of trenches at right angles to the supposed general bearing of the Lodes. This was done to a considerable extent last year, and resulted in the discovery of several Lodes.

Two of these, one of which contained Native Copper and the other Yellow Ore, were partially tested by Shafts No. 4 and 5. Three other Lodes which were found by the same means on a Trap range further into the interior than any previously explored, presented a favorable appearance at the surface, but nothing has yet been done to prove them.

In the absence of any prospect of *immediate* returns from Mamainse and the probability of a considerable capital being required to develop its resources and constitute it a paying Mine, it was thought advisable in the present state

and work discontinued.

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[2] Mr. Borron was manager of the Company's mines and works for five years, but resigned his position in 1857. The following reference is made to him in the Director's Report: "From ill health Mr. Borron last autumn announced his determination to resign his office of Manager. He left 1st December last, and has since been unable to proceed further than Sault Ste. Marie. Had it been possible, it was his intention to have met the Stockholders at the present Annual Meeting. The loss of the scientific head of the adventure, and one with whom the Directors worked with so much harmony, and in whom so great confidence was reposed, has occasioned them much concern; they have however doubted whether the now circumscribed limits of their operations warranted the expense of a Manager of Mr. Borron's attainments, and the staff hitherto employed by the Company."

ny's affairs to Lease the Mine should a favorable opportunity esent itself, and in the meantime to recall Capt. Hodge and the m at Mamainse. The party returned therefore about the latter ber.

Appearance of the lodes as shown by workings.

ing is a brief description of the appearance of the Lodes as various Shafts at the time of their suspension.

is Shaft is situated on the Vein where the first Indian Digd, and from it the 600 lbs. mass of Native Copper sent below well as 800 lbs. more in smaller pieces.

was from the very first small and insignificant in appearance, en more so as the Shaft descended. It carried no regular walls, nything but good indications at the bottom of the Shaft, which nches in depth. Last price for sinking the Shaft, £45 per

Shaft the Lode looked tolerably well according to Captain nt at the time it was suspended. The size of the Lode is from g, carrying a mixture of yellow and grey ore in quartz and r. The depth of this Shaft is 57 feet 6 inches, and price paid sinking from £24 to £27 Cy.

this Shaft nothing has been done since February last, when ned at the depth of 50 feet 5 inches, principally on account of ich was heavy. There was no striking improvement or change t the bottom of the Shaft. Last price for sinking, £22 per

ft was commenced last Summer on a run of yellow Copper ne Trap Range as that on which Lodes No. 1 and No. 2 are some distance North of No. 2. I examined it when I was there of July, and was rather pleased with its appearance on the sur-Hodge subsequently sunk about fourteen feet on it, and informs stopped the Lode was 5 feet in width, with regular walls, and well worth dressing, had there been Machinery and Apparatus itable for that purpose. Price per fathom for sinking, £25.

ortly before my last visit to Mamainse a Native Copper Vein overed on a range of Trap, some 150 fathoms east of that on Nos. 1, 2, 3 and 4 are situated, a strong bed of conglomerate sed between the two ranges. On inspecting this Lode, I was pressed with its appearance, and requested Capt. Hodge to put sink on it immediately. Before I left good specimens were hin a few feet of the surface, a small box of which I sent down n my return. Subsequently however the native copper disap-he Lode almost entirely. The lode itself continued about 10 nd carried to the last very promising spars and mineral soils. 25 ft. 2 in. in depth. The prices paid for sinking, £18 and om.

ding my remarks under this head, I have to observe that Company have been disappointed in their hopes of speedy re-is Mine, the operations carried on at Mamainse have tended

Confidence in the value of location.

to impress every practical man who has visited the Location with a favourable feeling in reference to the value and prospects of the property in a Mineral point of view, and I am firmly convinced that at no distant period parties will be found willing to embark further capital in the search for richer deposits of Copper than any we have yet been fortunate enough to find. I am equally certain that such richer Lodes exist on the Location.

Everything that was moveable in the way of Stores, Materials and Tools has been brought away, and the houses were left in charge of Charles Rousseau, [Roussain ?], who carries on a Fishing business at Mamainse, and contemplates occupying them during the Winter.

The balance at the debit of the Lake Superior Exploration Account is £1009 8s. 5d."[3]

Opinion of the Directors.

In their own Report (p. 5) the Directors say: "The explorations at Mamainse were discontinued in September last—their expense continued to exceed the anticipations of the Directors; and although new indications of a favourable character were discovered, sufficient mineral was not procured to guarantee a return for the expense of working, and the Directors did not think the finances of the Company warranted them in further outlay for experimental purposes. The remarks in Mr. Borron's report in regard to this location are deserving the attention of the Shareholders. The location enjoys a high reputation among explorers and others, and in case of a lease being made of the Bruce Mines the Company might be expected again to turn their attention to this locality. It is possible that enough of its resources have already been developed to induce capitalists to give it consideration."[4] But thirty-five years passed by before capitalists were found with courage to work the Mamainse properties again, and meantime the Montreal Mining Company had met with many reverses of fortune. The following notes of a brief visit to the Point last year will suffice to describe the situation.

NOTES OF A VISIT TO POINT MAMAINSE.

On board the Telegram.

On the 29th of August I left Sault Ste. Marie by the steamer Telegram on one of her semi-weekly trips to the fishing stations on the east shore of the lake as far north as Otter Head. This boat was formerly in the same business on Lake Erie, collecting catches of fish along the shores of Kent and Essex and around Pelee and the Bass islands for a large curing establishment at Sandusky. She is a staunch craft, as indeed she needs to be with a stiff breeze blowing the whole length of Lake Superior, from west to east, as pretty often happens in the autumn of the year. No other boat is regularly employed on the route, and so whatever freight or passenger business is to be done along the east shore the Telegram gets it.

Among the passengers were two or three men for the lumber woods, and a party of four or five who were going to examine a granite location near

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[3] Report of the Directors of the Montreal Mining Company to the Shareholders at the Annual General Meeting, 17th February, 1858, pp. 12-14.

[4] The cost of mining copper, including the expenses of management, is given by Mr. Borron on the quantity raised, dressed and shipped at Bruce Mines for the year 1857. The total quantity was 467 tons 13 cwt. 2 qr. 3 lb., estimated by analysis to produce 20 28 per cent. of metal; and the average cost on board at the mine was £17 6s. 3d., or say $69.25. This was equal to $3.41½ per unit, while the selling price was about $4 per unit.

a. One of the owners of the property is Mr. Joseph Cozens
Iarie. He had shown samples of the stone to Messrs. Cart-
f Detroit, who have large stone-cutting works in that city, and
twright was the leader of the party going up to prospect the
Cartwright is an amateur astronomer as well as a stone-cutter,
ave had precedence of Mr. Andrew Elvins of Toronto in the ob-
ch led to the discovery of the fifth moon of Jupiter. Like Mr.
ıas an opinion on the selfishness of Dr. Barnard of the Lick
who was enabled by the suggestions he had received to locate
through the great telescope at his command[5] Mr. Cartwright
eased with the samples of granite which Mr. Cozens had shown
rmed me that if the stone was to be had in quantity his firm
tain to purchase the property. As to working it, that might
tariff. "If cut-stone was on the free list we would have
chinery there before snow flies." I have learned from Mr.
ce that he was well satisfied with the location, and his firm
npt arrangements to buy it, but another party interested in the
Mr. Cozens demanded a price so far above its value that the
ere abruptly ended. Mr. Cartwright does not regret his for-
as he has learned enough of the region to satisfy himself that
ual if not greater value are to be had on the public domain.
ed very fine samples of granite in colors of gray, red and white.
Whitefish bay we met a heavy sea, the wind blowing strong
hwest, and the Telegram pitched and rolled in a most uncom-
or landsmen. But she kept steadily on, taking a northerly
Gros Cap, and getting in the lee of Isle Parisienne, and again
lands beyond it. Goulais bay lies to the eastward beyond Gros
ond a second headland is Batchawana bay, which extends
welve miles. A low island of the same name occupies a large
ay, while lying to the west is a gravelly headland which serves
bay from the prevailing west winds, the southern extremity of
n as Point Corbeau. We reached the landing at "Caribou" Cam-

A granite location near Cape Gargantua.

Northward to Batchawana bay.

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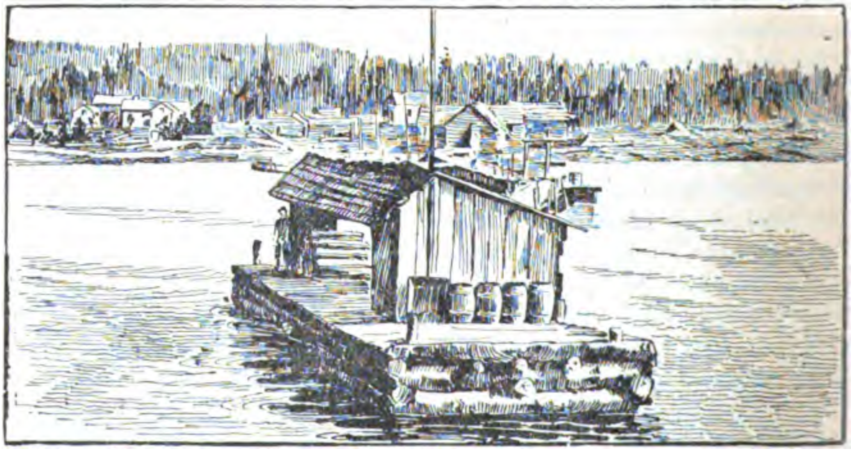
however to Mr. Elvins it is only proper that his title to rank as a discov-
ated, although it is not a matter strictly pertinent to this Report. Mr.
claim to priority upon the following documentary evidence: 1. A series of
rigin of the Solar System printed during 1872-3 in the Toronto Leader, and
s English publications, in which he enunciated the view that Jupiter and
e been and are throwing off matter which has, or will become, satellites,—a
y him, and revived by the interest being taken in the great Red Spot on
ery prominent feature on that planet. 2. A special paper on the subject
of March, 1891, before the Astronomical and Physical Society of Toronto
its Transactions for that year. 3. A letter written in December, 1891, by
. Barnard, to whom was also sent a little later a copy of the Transactions.
ue to some lantern-slides made from drawings of Jupiter by Dr. Barnard
Tennesee, and exhibited before the Society by Mrs. Proctor in November.
his theory Mr. Elvins suggested that during the approaching opposition of
ul search be made for new satellites. 4. A letter dated 2nd January, 1892,
rnard acknowledged the receipt of Mr. Elvins' communication and referred
and to the Red Spot. 5. Newspaper paragraphs originating in California to
on the resignation of Dr. Crewe, one of the Lick observers, in the summer
r a struggle with the authorities, Dr. Barnard had succeeded in obtaining
e of the great telescope. 6. After the discovery of the fifth satellite in
Elvins wrote to Dr. Barnard a letter in which, after alluding to various mat-
ith the discovery, he heartily felicitated the discoverer, and expressed the
e passed and still better telescopic facilities became available the Doctor
ther moons, of the existence of which Mr. Elvins had no doubt,—a cordial
which to this day has gone unnoticed.

eron's old mill site at 8.30 p.m., after a run of six hours from Sault Ste. Marie, and tied up for the night. Next morning at 5.30 we steamed up to the head of the bay, past the Batchawana and Harmony rivers, and unloaded a cargo of supplies for Perry's lumber camp. The bay is surrounded by high ranges of hills, which in places recede a mile or more from the shore and in places overhang the water's edge, but everywhere they are thickly covered with small timber. While the boat was unloading I walked with Mr. Cozens some distance out on the lumberman's road, and noticed that the soil was a rich black mould on which the grass grew luxuriantly. The timber is small, being apparently a second growth, but it is very dense. The pine forest is some distance back from the shore. The waters of Batchawana bay north of the island are shallow, and there is great risk of running on shoals. We left Perry's Landing at 9 o'clock and reached Sand bay at noon, a distance of 37 miles. The round headland west of Batchawana bay is composed of gravelly drift, but beyond it is what appears from the steamer to be an outcropping of sandstone, with a beach of yellowish sand extending northwestward several miles into Pancake bay (Anse aux Crepes) —the southern boundary of the Pancake mining location. Several high ranges of hills run parallel with the shore, covered to their summits with timber. At the highest point, about 1,300 feet above the lake, surveyors in the employ of the United States Government have planted a station for triangulation work. We took on board the officer in charge of this party near the Sand islands on the return trip.

Good land at the head of the bay.

From Perry's Landing to Sand bay.



15. Roussainville, on the Mamainse headland.

Pancake Point, on the west side of Pancake bay, is the most southerly part of the Mamainse headland, the shore line of which runs northwestward and northward by Whiskey Point to Point Mamainse, above Sand bay. One mile north of Whiskey Point is Roussainville, a fishing station, which is headquarters for Captain John Roussain, who holds a license to fish from the Point to the northern boundary of Sand bay location.

Roussainville.

Sand bay is a beautiful half-circle sheet of water on the south side of the mining location of that name, half a mile wide from Copper Point on the

Sand bay.

neral Point on the north, having a shore of yellow sand, and pered on the east and south. Its waters are shallow, and boats ty of the Telegram cannot get nearer the shore than 400 yards. side, near a wide sand beach, are the office and warehouse, a ng house and the mining manager's residence, all built of squared nd which rise a succession of nearly parallel ranges of rocky

Proprietorship of Pancake and Sand Bay mining locations.

ake and Sand Bay locations have a shore line of nine miles— vith five and a half miles and an area of 4,800 acres, and the hree and a half miles and an area of 6,400 acres. They were n the Crown by the Montreal Mining Company in 1856, at forty e. On the 13th November, 1871, the Montreal Company sold teen other locations for $225,000 to the Ontario Mineral Lands terwards merged into the Silver Islet Consolidated Mining and ny. This company in the course of time became disabled by s, and its property was taken over by the bondholders, who in April, 1890, sold it to a syndicate known as the Canada Lands e manager of which is Mr. Sibley of Detroit.

THE MAMAINSE HEADLAND.

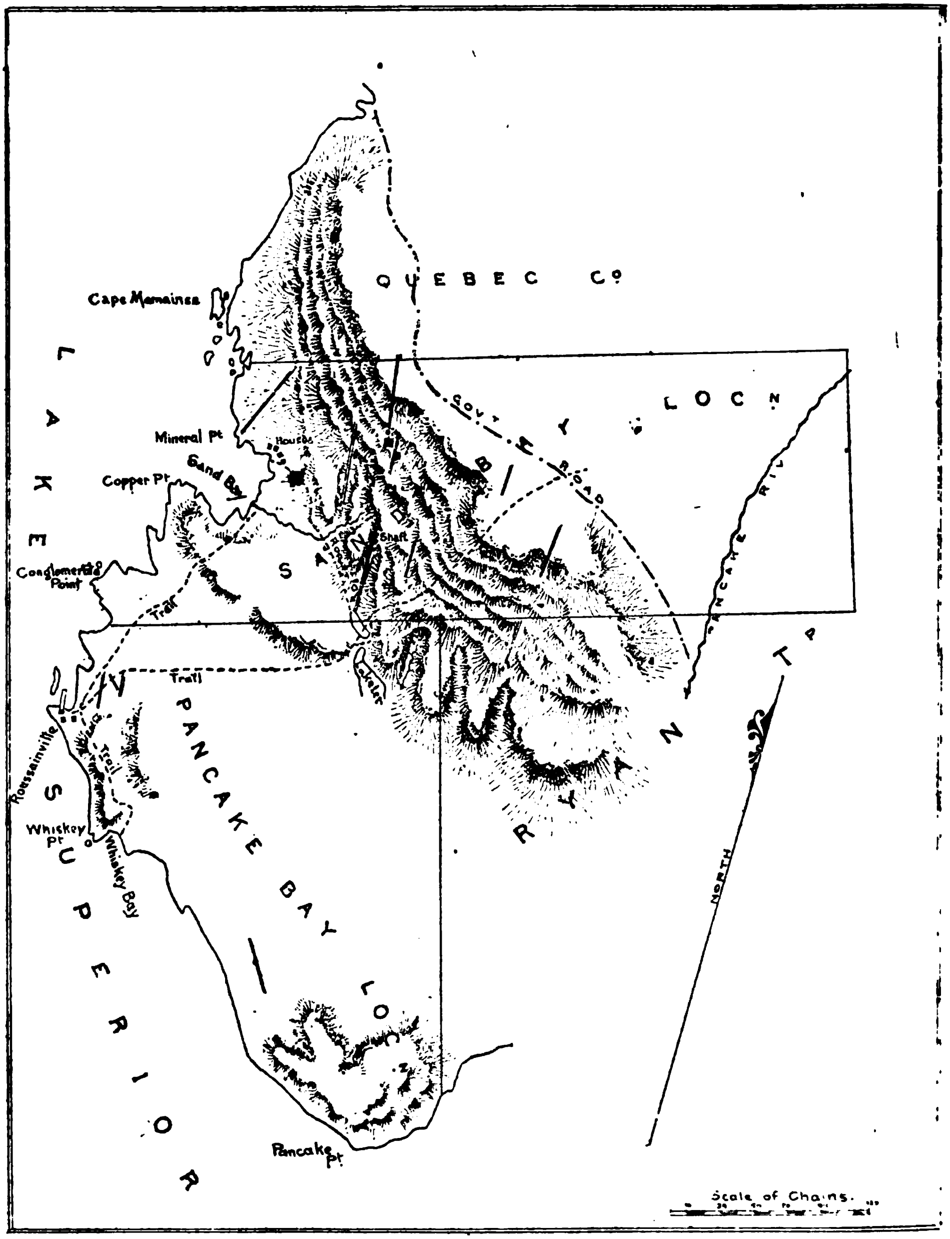
Keweenaw or Copper-bearing rocks constitute the headland.

ainse peninsula or headland lies between Sand bay and Pancake Canadian geologists have distinguished the rocks composing it as Copper-bearing series, while the later American geologists have term Keweenaw series, from their conspicuous occurrence on Point on the south shore of Lake Superior—the locality of the higan copper mines. The American geologists also divide the Upper and Lower divisions, copper ore being confined almost e latter. The Keweenaw peninsula, as well as Michipicoten he Mamainse headland, are in the lower division. Indeed the nt difference between the north and south shores at these points e the beds on the Ontario side dip towards the south and southn the Michigan side dip towards the north and northeast, formo the ends of a great synclinal trough in which lie the waters of or. Captain Tretheway has found the eastern end on Mamainse e Huronian schists, whose outcropping is four and a half miles e camp on Sand bay. On the Pancake location there is an outsandstone along the eastern side, but it is uncertain whether it he Keweenawan series or to the overlying Potsdam which thward from Sault Ste. Marie and Whitefish Point. From e to Copper Point on Sand bay, along the lake shore, the successrap and conglomerate are clearly exposed, lying in a course of nd southeast and dipping towards the southwest at an angle of No change of level takes place in the first mile from Roussain-00 yards back of the camp at Sand bay a bald bluff of trap ss the location from northwest to southeast. It rises gradually east, where it is overlaid by a bed of what appears to be altered t in reality is a felsite or quartz porphyry, reaching at its high-

Exposed sections of eruptive and sedimentary rocks composing the series

Traps, conglomerates, felsites, etc.

est point 250 feet above the waters of the bay. Here it is of a light red or brick color, hard, fine-grained and marked with what appear to be lines of lamination, twisted and curved into a variety of beautiful forms under



16. Map of Mamainse headland. The parallel lines show location of mineral veins.

pressure, but which more probably is due to flowage in a molten state.[6] Dr. Coleman has furnished me with the following description of it :

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[6] In the Geology of Canada (p. 81) Logan describes similar beds which he found on narrow islands on the south side of Michipicoten. The beds are sixty to seventy feet thick and dip southward at an angle of 20°. "They are of a general red color, spotted and

scopically this rock appears to be made up of a series of thin layers
and yellowish material thrown into gnarled and corrugated forms.
a whole has felspar hardness, though the yellowish layers are
ofter than the rest. Under the microscope quartz is distinctly
etimes as minute grains, at other times as porphyritic blebs or
few greenish portions of chlorite occur also; but the mass of
nsists apparently of a mixture of quartz and kaolinized felspar,
rged with particles of iron oxide. The yellowish layers consist
ly of the decomposing felspar. The rock, which has a superficial
to some jaspers, is apparently a felsite or quartz porphyry which
ushed and rolled out, or a very siliceous volcanic sediment. It
fairly well with the rock described by German and Scandinavian
illeflinta."[7]

at the line of contact with the felsite rises in a bluff about
feet above it, and thence slopes gradually upward to a height of
seventy-five feet. The felsite is apparently very susceptible to
es of the weather, for where exposed it lies on the face of the
ke a mass of shingle. It is overlaid as well as under-
p, and farther down the slope is a bed of somewhat similar rock
ying from purple to yellowish white, but essentially different.
describes it as "a compact, wavily stratified greenish rock, soft
easily scratched with a knife. Under the microscope a few
les of quartz show themselves, but the rock is seen to consist
rbid grains, apparently of dolomite, and tiny scales of talc. It is
reatly weathered, and may represent a metamorphosed basic

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ellowish white, and wherever a crack exists the rock is blanched to a small
h side of it. The surfaces are uneven, and peculiarly marked with festooned
nkled forms, composed of very thin close-fitting laminæ, with a ligneous
a thickness sometimes exceeding one or two inches. The rock scarcely
p, nor does it bear the character of indurated shale; but it may perhaps be
nixture of volcanic mud and ashes, in which the wrinkles result from a partial
acfarlane examined the same beds in 1865, and describes the rock as trachytic
rt of 1866-9, p. 142); while Irving in his monograph on the Copper-bearing
Superior (p. 313) found it to be "a highly siliceous felsite, closely resembling
onging with the red rock of which Mount Houghton on Keweenaw Point is
makes up much of the central mass of the Porcupine Mountains, and which
of the red cliffs of the Minnesota coast of Lake Superior. The resemblance
copic and microscopic; while the peculiar 'festooned and wrinkled' markings,
ery thin, close-fitting laminæ with a ligneous aspect,' noticed by Logan, are
I have repeatedly described in the foregoing pages as characterizing similar
ny places in the western half of the Lake Superior basin. These markings
ue to a viscous flow, and are much the same as are found to characterize the
tes." For further description of the lithological character of rocks of the
eries Van Hise deserves to be quoted. "The felsites, quartz-porphyries and
s—in the earlier reports frequently called jaspers—and amygdaloids were by
rlier authors supposed to be metamorphosed sandstones. This position is, I
acid rocks, held by no writer at the present time, with perhaps one exception,
mygdaloids by none. The work of Wadsworth, Pumpelly and Irving has
beyond all doubt that these rocks are original eruptives. The Keweenawan is
recognized as a series many thousands of feet thick, consisting of interbedded
water deposited detrital material, derived chiefly from the contemporaneous
The volcanics are predominant in the lower part of the series, the inter-
of the two are most frequent in the middle portion, and the upper part of the
om volcanics." Bulletin No. 86, U. S. Geological Survey, p. 161.

e or felsite (eurite and petrosilex of continental geologists), an intimate mix-
and silica, forming a compact rock, chiefly of dull, opaque yellow, gray,
lors. It might at times be mistaken for a metamorphic quartzose rock, but
nguished by its easy fusibility, relative hardness, and its weathered, bleached
mon among the Silurian rocks of Wales and Cumberland; the Pyrenese;
alleflinta is a flinty, fissile or laminated variety of felstone." Prestwich's
, p. 40.

volcanic ash. It might be called a talcose dolomite or a dolomitic soapstone." This band outcrops for 80 or 100 yards along the road which leads to Copper Creek mine. From the bay to this point is a little more than half a mile. The road continues to rise, crossing alternating beds of conglomerate, amygdaloidal trap and common traps of various colors, until the mine on Copper creek is reached at an elevation of 275 feet above the bay.

A medley of traps.

The whole front of the location on the lake side northward of Mineral Point is a mottled trap, in places of a greenish and in others of a dark reddish or purplish color ; but at a small lake near the upper boundary line, which is separated from Lake Superior by a wall of rock 25 yards wide, the trap changes to green and is of an amygdaloidal character. A well beaten path leads from this lake direct to the camp on Sand bay, crossing on the way a low ridge of trap of considerable breadth. A point of trap which runs down to the bay to the west of the camp is in its upper portion of black or dark green color and of uniform crystallization, but at a depth of about ten feet the color changes to purple and it is filled with amygdules of calcite. On the eastern side of the bay the trap is of the same character as that on the lake side, both in color and lustrous mottling. The mottled appearance suggests that the rock is a species of conglomerate, there being dark pebble-like bodies of hard substance imbedded in a matrix of green. The latter from its comparative softness wears more readily away, leaving the harder nodules to stand out like small mamillations over the face of the rock.

A DIFFICULT REGION TO EXPLORE.

An arduous task for the prospector,

The southern part of the Sand Bay location it is said was burnt over about 37 years ago, when the Montreal Mining Company was prospecting it, but it is now clothed with a very thick growth of spruce and poplar. Farther back it is densely timbered with cedar, spruce, pine, tamarac, black birch and hard maple, so that is with difficulty an explorer can enter it without cutting his way as he goes. The ground too is covered with a tangle of roots, fallen timber and branches, as well as with moss and leaves, and none but the most experienced prospectors can venture to explore it with any hope of success.

and how he accomplishes it.

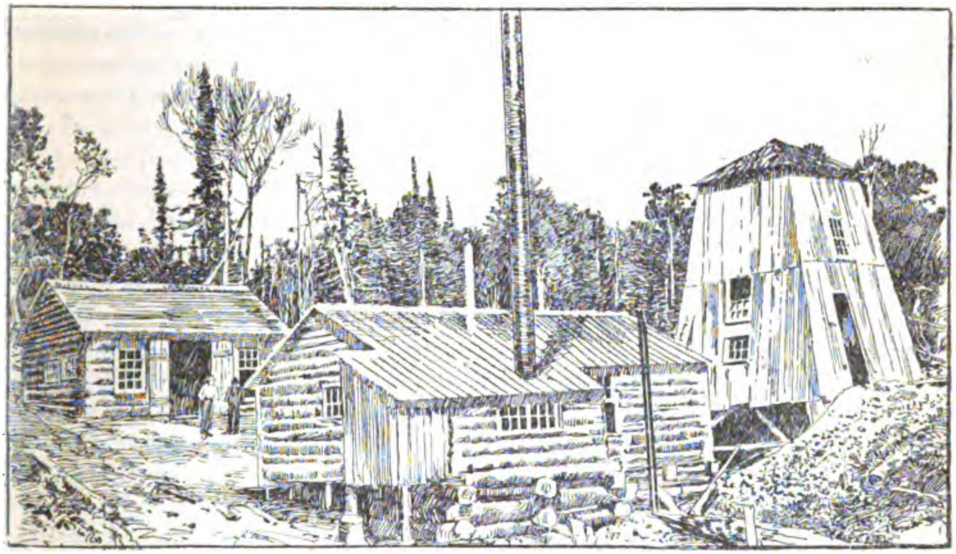
Captain Trethewey however has found that by conducting operations in the winter, on snowshoes, and carefully noting the notches and depressions in the ranges of hills, he is able to accomplish much more than is possible in summer, when the deciduous trees are covered with foliage. The veins have nearly all a north and south course, crossing the formations, and the country rock along their line having been disturbed and washed down at many points the whereabouts of a vein is often clearly defined. Especially is this the case on the crowns of ranges, the line being so distinct as to suggest its having been cut out by the hand of man. Almost all of the thirteen or fourteen veins discovered by Captain Trethewey, he states, have been indicated to him in this way, and in almost every instance his discoveries have been made in the winter season. In spring or early summer he goes over the ground, sinking pits and cutting trenches to verify the winter exploration, and cutting out paths to make future traverse easy.

PROGRESS OF DEVELOPMENT.

Early operations on the properties.

The first improvement of the Mamainse locations was undertaken by the Montreal Mining Company, under the direction of Mr. Borron, when five shafts were sunk on different veins on the range a quarter of a mile northeast of the bay. The particulars of this work and the reason for stopping it are given in the extracts from the Company's Report for 1857. The properties were not touched again for a period of seventeen or eighteen years, when a small gang of men was sent down from Silver Islet to explore the Pancake location, but no discovery appears to have been made by them. In the spring of 1882 however the Silver Islet Company entrusted the task of examining the properties to Captain Thomas Henry Trethewey, and with the help of five to ten men he continued exploration work till the spring of 1884. A number of mineral veins were discovered by him, but most of the time was wasted in searching for silver, owing to a small discovery of that metal having been made. Two shafts were sunk on a conglomerate bed at Roussainville to depths of 65 and 87 feet respectively, but the copper ore taken out yielded less than one per cent. An opening upon No. 11 vein on Sand Bay location discovered samples of ore which by analysis yielded many thousands of dollars of silver per ton, yet the aggregate was very small; some samples of copper glance however were found to run 70 per cent. in copper. From this time no further work was attempted until December, 1891, when the new proprietors employed Captain Trethewey to explore Sand Bay location with a diamond drill. Operations were carried on for ten months, during which time borings were made on four veins and five mineral beds ranging in depth from 60 to 365 feet and attaining an aggregate of 3,665 feet.[8] The beds were amygdaloidal trap and conglomerate, all of which

Time wasted in a vain search for silver.



17. Copper Creek Mine, on Sand Bay location.

Enterprise of the new proprietors.

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[8] The average cost of the drilling was $2.86 per foot, including plant, roads, buildings, expert examination and travelling expenses of Detroit officials; in short, every expense in connection with the work. The diameter of the core is about one inch.

Diamond drill exploration.

Sinking a shaft on the Copper Creek vein.

gave cores yielding more or less copper. The results were so promising that the syndicate decided to undertake development work on a larger and more satisfactory scale. Accordingly an outfit consisting of a 40 h. p. boiler, a 30 h. p. hoisting machine, a four-drill air compressor, car, pumps and a full mining equipment, together with camp supplies for the winter, were purchased and shipped to Sand Bay in November, 1892. The boat delivered its cargo on the 18th of the month, and on the 16th of January the work of sinking a shaft was commenced—an engine house, a shaft house, blacksmith's shop and two boarding houses having been erected in the interval. The site of the shaft is on vein No. 10, or the Copper Creek vein, about a mile and a half from the bay. The vein has a north and south course, cutting across the beds of country rock which have a strike of southeast and northwest. Two small streams join near the shaft house, to run southerly along the vein, upon which a channel several feet deep has been cut. The conglomerate bed forms the hanging wall at the mouth of the shaft, and a cross-cutting eastward shows it to have a thickness of 45 feet, with underlying trap beyond it. The footwall is amygdaloid. Near the junction of the streams the exposure appears to show a thrust or fault in the formations of about 50 feet, but the overlying drift hides the actual position. The vein dips toward the east at an angle of 45°, and is continuous at that angle to the depth (on 31st August) of 295 feet. The width too is equally uniform, being at the surface 6½ feet and at the bottom 6 feet 2 inches. At 80 feet, where a level has been driven southward on the vein 49 feet and northward 20 feet, the vein has passed into the underlying bed of trap, but the walls are well defined on both sides. Here a sump has been sunk in the north level, and a steam pump lifts the water draining into it to the surface. The shaft is dry from the 80 foot level down to 270 feet, but there the water pours in so fast as to make the placing of another pump necessary. The perpendicular depth from the surface at 295 feet, as indicated by an aneroid barometer is 200 feet; by calculation, assuming the accurate dip of the vein to be 45°, it would be 208 feet. The vein matter consists of traps, amygdaloids, conglomerates, quartz and calc spar, holding metallic copper and copper sulphides; but the rich ore occurs only in pockets, and the extent of it is uncertain. This can only be shown when levels are driven in and stoping begins. There is however a good sized pile of rich ore on the surface, and much of the vein matter thrown out on the dump contains ore of greater or less richness.[9] The shaft is 6 feet by 14 feet, and work had been carried on in it without interruption by day and night shifts from the 16th of January to the time of my visit, or 194 working days. This would give an average progress of a little more than one foot and a half per day, or the raising of 128 cubic feet; but it was somewhat more, as the work done during the period included

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[9] Mr. Sibley informs me that later explorations have demonstrated the fact that the mineral-bearing parts of the veins have an oblique course downward, and nearly parallel to each other. If this is the case it may account for the apparent failure of the lodes in depth, noted in Mr. Borron's report on the explorations of the Montreal Mining Company, as well as for the alternating barren and enriched sections of the vein as shown by the deep Copper Creek shaft.

9 feet and the sump for collecting water, putting in pumps, etc.[10] ressor was worked during the day shift, drilling ten holes an h of five feet. The charges were fired at the end of the day's n electric battery, when enough rock or vein matter was disep the night shift employed in hoisting to the surface. All the f the mine was in good running order, and its operations were ed for the prevention of accidents,—the best evidence of which by the fact that no accident had occurred in or about the mine 31st of August; nor has any been reported since.

Extent of Copper Creek vein.

per Creek or No. 10 vein has been traced north from the shaft 1¼ mile, and south 1,700 feet by pits and trenches, and at various ws fine ores. About three-quarters of a mile north of the shaft has been discovered upon which openings have been made that re for 1,000 feet. Some samples taken from the pits are copper ng as high as 70 per cent., and there are also showings of metallic the surface. The vein runs so close to No. 10 or Copper Creek e two are supposed to unite at a point beyond which the exploration been made, or possibly they are only parts of the same vein y a horse of the country rock.

Other fissure and bedded veins on the location.

re veins on the location have a north and south course except two or three have been traced across the boundaries either into ation or into territory not yet taken up in the township of 4 vein, which comes out on the lake at Mineral Point, runs west east of north, across the stratification. The gangue is trap and e and is fully 20 feet wide, dipping southeast, and carries native sulphide. A shaft has been sunk upon it to a depth of 40 ost of $8 per foot. At the extremity of the Point, where a vein about 15 inches wide assumes a whitish color, it is said small percentage of strontium. The bedded veins of course e stratification, and as already stated some of them have been he diamond drill to carry copper. On a small island in the om Roussainville, I was told by the captain of the Telegram discovered a lump of native copper in place.

THE LAKE SUPERIOR BASIN.

Differences of opinion among geologists on the relations and determination of rocks.

ing the structure of the Lake Superior basin, as well as the order ation of its rocks, there has been wide division of opinion among Between Irving and Macfarlane, for instance, there are constant s to determination of the copper-bearing rocks; due no doubt to method of identification by chemical analysis, and the former's by ope. The fact is however that the science of petrology has created since the investigation of Lake Superior rocks by Mac-

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ft has been sunk to a total depth of 308 feet, the average cost of which is r. Trethewey to be $8.50 per foot. The five exploratory shafts put down by Company, ranging in depth from 14 to 59 feet and aggregating 206 feet, cost $17.50 per foot. As cost increases with the depth, the advantage of improved ds in mining is obvious.

farlane nearly thirty years ago; certainly very great advance has been made in it with the help of the microscope. In the relation of the Animikie to the Keweenaw or Upper Copper-bearing rocks there have also been wide differences, but they do not need to be touched upon here. The late Mr. Irving of the U. S. Geological Survey was frank enough to confess that his own opinions on the structure of the Lake Superior basin had undergone several changes from the time when his studies of them first began in 1873 down to the completion of his memoir in 1882, and possibly had he lived a few years longer his views might have undergone further modification. His matured opinion, which does not differ much except as regards details from the opinion formed by Logan in 1847, is contained in the following extracts from his monograph on the Copper-bearing Rocks:

Irving's final conclusions.

"At the beginning of my study for the present memoir, North Wisconsin had been shown to be traversed by a broad synclinal in the Keweenawan rocks, possibly also in the Huronian, which was presumably the continuation of the Isle Royale-Keweenaw Point depression. The exact nature and position of the western termination of the synclinal, the relation to the synclinal of the rocks of the Minnesota coast, and of the Porcupine mountains, and the behavior of the depression to the eastward of Isle Royale, were all points left in doubt, though it appeared exceedingly probable that the entire western half of the Lake Superior basin is a synclinal depression affecting both Huronian and Keweenawan rocks.

A synclinal depression throughout the entire extent of the Keweenawan rocks,

Now however I feel able to announce with confidence that the entire lake basin, including not only the western half, but the eastern half as well, is a synclinal depression; that this depression certainly affects the Keweenawan rocks throughout their entire extent; that it as certainly affects in very large measure the underlying Huronian rocks, which, while they are greatly folded where extending without the limits of the depression, within its limits form without folds its bottom layers; that the axis of the depression has, like the lake itself, at first a northwesterly and then a southwesterly direction, with minor bends corresponding to the several bends in the axis of the lake; that the eastern terminus of the depression is buried beneath the newer formations in the vicinity of the Sault Ste. Marie; that the western extension passes on to the south shore of Lake Superior with a course curving more and more to the southwest until at the termination in the St. Croix valley, and therefore without the present hydrographic basin of Lake Superior, it becomes nearly due south, the exact termination here again being buried beneath the newer horizontal Cambrian formations; and that in the region of the Porcupine mountains of Michigan and the Douglas County Copper Range of Wisconsin, there are minor folds superinduced upon the grand synclinal, accompanied in the former case at least by further complications, due to faulting.

which also affects the underlying Huronian rocks.

The evidence upon which these conclusions are based is to be found in (1) the nearly constant dip inwards of the Keweenawan strata towards the middle of the basin; (2) in the frequently similar dip of the Huronian; (3) in the the constant order of Upper Keweenawan, Lower Keweenawan, Huronian and

18. Hypothetical section of Lake Superior basin.

gneiss with granite and folded crystalline schists, met with on all sides on going from within the supposed trough outwards; and (4) in the parallelism between the courses of the Keweenawan belts of the north and south shores and of the shore line within these belts." [11]

And referring more particularly to the Huronian formation, Irving says:

Relation of the Huronian to the synclinal.

"The relation of the Huronian to the synclinal is a point of great interest. Beyond question, in the western half of the Lake Superior basin, it bottoms the great trough, for its beds are found dipping inwards on both sides; on the north shore at a low angle, and on the south generally at a high one. It appears highly probable that the eastern part of the trough is similarly bottomed by the Huronian. The Huronian beds are however here found, just without the rim of the synclinal, folded in a complicated manner; for instance, beyond the western end of the trough in Minnesota, in the iron regions of Michigan, on the east shore of Lake Superior, and about the head of Lake Huron. Other folded schists, which possibly belong with the Huronian, occur in Canada north of Lake Superior. The connection of these folded beds with the unfolded is a structural problem still needing investigation." [12]

Hypothetical section of the Superior basin.

To illustrate more clearly his idea of the Lake Superior basin, Mr. Irving presents a generalized hypothetical section of it which may be looked on as taken across from Pigeon River region of the north shore, through Ontonagan, the South Range, and the Menominee region of Michigan and Wisconsin, but not on a straight line, and not drawn to any scale, in which he has attempted to bring out the following points: "(1) The synclinal structure of the lake basin; (2) the partial unconformity of the Keweenawan to the unfolded Huronian; (3) the supposed relations of the folded and unfolded Huronian; (4) the limitation of the Keweenawan outwards by the higher Huronian land; and (5) the origin of the Keweenawan eruptive rocks through fissures arranged around the rim of the trough. If this sketch represents actual conditions, then the downward bowing of the great trough, which subsequently was filled with the Keweenawan accumulations, was begun in the Huronian and continued through the Keweenawan. Accompanying this downward bowing was a crumpling of the Huronian to either side of the broader bow—and this crumpling, so far as this sketch is concerned, may have taken place in large measure before the Keweenawan—and an extravasation of molten matter around the rim of the trough." [13]

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[11] Copper-bearing Rocks of Lake Superior, pp. 412-413.
[12] Ibid p. 417.

SIR WM. DAWSON'S EARLY VIEWS ON MAMAINSE.

Professor (now Sir William) Dawson visited Point Mamainse in 1856, and wrote a very interesting paper upon it for the Natural History Society of Montreal. The following extract deals with the geology of the promontory, and the mode in which native copper was deposited in the veins:

Geology of the east shore to the Mamainse headland.

"The promontory of Maimanse is high and rugged in its interior, and in approaching from the east its outline presents a series of abrupt protuberances. This appearance is caused by the outcropping edges of thick beds of trap and conglomerate, which have, better than the associated tufa and sandstone, resisted the denuding agencies, which in this region appear to have most thoroughly swept all the elevated tracts, scooping out the soft beds and carrying off all the finer materials, as if the forces of breakers and strong currents had been combined in the operation, along with the drifting agency of ice.

At Pancake bay.

In a point at the west side of Anse aux Crepes [Pancake bay], the beds of sandstone and trap are seen in a less disturbed state than in the bay itself. Two very thick beds of amygdaloidal trap are here exposed, and between them are bands of brown ripple-marked sandstone and volcanic tufa. The whole dip west at an angle of 15°. The amygdaloids are evidently superficial lava currents, presenting in some places those pipe-like cavities described by Sir W. E. Logan in his account of this place, and which must have been caused by air bubbles rising through the superficial molten mass. The amygdaloid is much more vesicular above than below, and its cavities and veins are filled with agate, crystalline quartz, calc spar, and flesh colored laumonite.

The shore for some distance follows the strike of these beds, in which the waves, acting on the tufa and mineral veins, have excavated many small caverns and ravines. Some of these excavations are at a little higher level than that of the waters of the lake at present: and they are very instructive in the explanations which they afford of erosions observed even on the summits of the hills.

At Mamainse or Sand bay.

Five miles westward of Anse aux Crepes the ledges of the coast are broken across, probably along the line of a transverse fracture of the beds, to form the little bay of Maimanse [Sand bay]. On the east side of this bay we find another section of trappean and sedimentary rocks, apparently a little lower in the series than those of Anse aux Crepes. The highest bed of trap is amygdaloidal above, and more compact below, where it rests upon a brown conglomerate with syenitic pebbles, and thin layers of brown sandstone. The

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[13] Copper-bearing Rocks of Lake Superior, p. 418.

Traps and conglomerates.

s of grains, often rounded, of quartz, felspar and hard black
by peroxide of iron, and cemented by carbonate of lime, which
to the cement of the conglomerate. The conglomerate rests upon
f trap, which in its upper part is largely amygdaloidal, and con-
gates. It also holds syenitic fragments, probably mixed with the
natter of its surface, at the time when the conglomerate was
ve, so that, as is often seen in such cases, the upper part of the
into the conglomerate. These rocks present no appearance of
ation subsequent to their deposition, and dip s. 70° w. 35°.

ad of the bay, and at its western side, the sections show alterna-
pact and amygdaloidal trap and hardened volcanic ash, in very
s ; and holding numerous veins of calc spar, laumonite and quartz,
uantities of epidote, prehnite, sulphurets and carbonates of cop-
opper, native silver and galena ; the mode of occurrence of which
ed hereafter. The numerous alternations of thin sheets of trap
t appear in the low ground around this bay indicate a long con-
s of submarine volcanic overflows, while the rounded pebbles in
erate point to a rocky Laurentian shore at no great distance.
ns to be done in this region in separating those igneous beds which
ed of volcanic ash and scoriæ from those which are properly trap-
his is rendered very difficult by the consolidation of the fragmen-
zeolitic matter, and by the resemblance which hardened volcanic
ds of vesicular scoriæ bear to true overflows of amygdaloidal trap-
the changes induced in true igneous rocks by the percolation of

Section of rocks from Sand bay inland.

head of the bay the ground rises rapidly to a height of 300 feet,
on of steep ridges, representing the outcrops of the beds which
other in descending order. The section from the n.-w. extremity
nland is as follows, the measurements being taken from a plan
Mr. Coatsworth of the Bruce Mines for the Montreal Mining
ho are now carrying on works of exploration at this place. The
the westward, the general strike being n. 10° to 20° w., and the
p varying from 25° to 35°. The rocks are, as usual with such
ery unevenly bedded.

nations of trap and tufa, with a bed of conglomerate, which
un out a little to the westward of the line of section, in which it
ear. Large veins of calc spar, quartz and laumonite occur in the
me of them contain small quantities of native copper, native silver
Native copper also occurs in the vesicles of one of the amygda-
ne thin bed has its vesicles filled with a steatitic mineral. These
y a breath of 500 yards.

lo-arenaceous beds, in places baked into a compact jaspery rock
olor, with red dendritic stains, in other parts a mottled argillaceous
imilar to that of Anse aux Crepes. Breadth 220 yards.

talline and amygdaloidal trap, with a bed of conglomerate.
s occupy a breadth of 440 yards, and rise to an elevation of 300

feet. The old Indian workings and the excavations of the present mine are on the summit of this ridge. The lowest rocks of this band are probably tufaceous, and have been excavated into the ravine of a small brook.

4. Very coarse syenitic conglomerate, forming a second ridge. Some masses of stone two feet in diameter were observed in this bed. It occupies a breadth of 160 yards.

The thickness represented by these measurements may be about 2,000 feet; but this by no means includes the whole thickness of similar rocks developed at Maimanse, and which extend both above and below the beds above described. The total thickness seen at Maimanse is estimated by Sir W. E. Logan at 10,000 feet. [14]

Occurrences of copper in ranges of trap.

The beds included in No. 3 of the above section are those in which the principal indications of copper have been observed. On the summit of the ridge the hard semi-crystalline trap is traversed by a narrow fissure, running nearly with the strike of the beds, or north and south. Its greatest thickness is about six inches, but in some places this has been found to be nearly filled with native copper. One mass weighing 600 pounds has been extracted, and the whole yield of a shaft 27 feet deep and without galleries has been about three tons. The veinstones here are principally calc spar and quartz.

Indian diggings

At a short distance westward of the shaft the vein is divided into two branches. The course of this vein, as well as of most others in these hills, is marked by surface trenches, usually called 'Indian diggings,' though they are evidently erosions similar to those which run along the veins seen on the present beach, and excavated when the surface was undergoing denudation under water. These trenches however afford excellent guides in tracing the veins, and they have served this purpose to the ancient Indian miners, in whose time it is likely that plates of metallic copper, exposed by the removal of less resisting materials, may in places have projected from the bottom of these furrows. The real Indian diggings are shallow holes, sunk at intervals along the courses of the veins, and surrounded by broken pieces of veinstone, along with which are occasionally found stone hammers. These hammers are merely beach pebbles, usually of trap, and having shallow grooves worked around them, to receive withes or thongs used as handles. Most of them are 5 or 6 inches in their longest diameter, but one now in the collection of the Geological Survey, is about a foot in length.

About one hundred yards northward of the shaft just mentioned excavations have been made at the intersection of two veins, one running N. W. and S. E., and the other N. and S. The former is unproductive; but the latter, which is six inches in width, contains small bunches of purple copper, in a veinstone of quartz and calc spar. A few small crystals of copper pyrites have also been observed in it. About 30 yards eastward from the second opening is another vein, running E. 20° N., and wider than either of the others. Its principal mineral contents are green carbonate of copper, with a little per and copper pyrites. A few minute specks only of native cop- n observed in it. It appears to be very irregular in its width, place where it has been opened the wall on one side consists of and that on the other of compact trap, probably in consequence

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[14] Dr. Robert Bell estimates the thickness at 22,400 feet. Geo. Sur. Report, 1876-7, p. 214.

A multitude of fissures.

l appear that this ridge is traversed by a multitude of fissures, opper and copper ores, and as is generally the case with such veins irregular in course and dimensions. Those above described are siderable yet discovered. Their value as deposits of copper is not ed ; but the indications are of sufficient promise to warrant works on. The quality of the veins will no doubt change as they pene- lerlying tufa and conglomerate, though whether in the direction less value is uncertain.

MODE OF DEPOSITION OF NATIVE COPPER.

The metal deposited contemporaneously with the gangue of the vein.

mode of deposition of native copper has been a subject of much I examined with care, with the aid of Mr. Borron of the Bruce ins exposed at Maimanse, and shall state the results at which I for that locality, with the facts on which they are based, with- to assert that the mode of occurrence and formation of native in all cases have been of similar character. The veins traversing Maimanse have been filled with successive deposits of mineral eir sides, in the manner of ordinary mineral veins. In the larger re alternate layers of quartz and calc spar, the latter often moulded alline surfaces of the former, and *vice versa.* In several cases the of quartz is of an agatiform character, and stained by peroxide of greater part both of the quartz and calc spar is crystalline and

osition of the native copper has evidently been contemporaneous sequent to that of the quartz and calc spar. The larger masses d in calc spar, occupying the cavities left in the wider parts of the ts sides had been coated by that mineral. Smaller masses occur relation to the quartz. In one of the beds of amygdaloid are ker- er impressed by crystals of zeolite, which had lined the vesicles o the deposition of the metal. In one small vein plates of copper e veinstone of quartz. Such examples indicate deposition of cop- at of the veinstone. In other specimens delicate arborescent copper penetrate calc spar crystals in such a manner as to give ral red color, indicating contemporaneous deposition.

. . . .

silver occurs on the shore in small quantity, in similar dendritic vein containing calc spar, zeolites and fragments of trap. The f copper occur in precisely the same relations with the native carbonate is probably a product of oxidation of vitreous copper opper near the surface of the rock.

nes)

The whole of the appearances indicate that the deposition of copper belongs to the period of aqueous infiltration, by which the veins and vesicles were filled after the consolidation of the trap; and the copper, like the calc spar and zeolites, occurs both in true veins and in the cavities of beds of vesicular trap and tufa. Its deposition must therefore be explained, not by igneous causes, but by electro-chemical agencies, decomposing some soluble salt, most probably the sulphate, of copper. Such changes may have been aided by the remaining heat of portions of the volcanic masses, by the presence in them of large quantities of iron in low states of oxidation, and by the further oxidation of that metal evidenced in the red jasper and red laumonite of the veins, and the red conglomerate and sandstone associated with the trap.

Probably a result of electro-chemical agencies.

One great difficulty in supposing the electro-chemical deposition of copper in these veins is the want of a conducting surface, and one not likely to be acted on by copper salts, for the commencement of the process. Much of the copper however, even when not exposed to atmospheric action, is coated with suboxide of the metal; and I have in several instances observed the crystals of calc spar in these veins varnished with a thin coat of peroxide of iron, or of suboxide of copper, which has been precipitated on their surfaces, and might have formed a better basis for copper deposition than the naked surface of the calc spar. In the delicate dendritic forms the crystallization has evidently commenced from minute points; and this may have been the case also with some of the larger masses, which often have thin plates of fibres connecting them with the wall of the vein. Such connecting threads, if first deposited may have served as conductors.

Such attempts at explanation must however in the meantime be regarded as merely conjectural; and it must be confessed that we can have little accurate conception of the processes that may go on in fissures extending from the bottom of the sea far downward into volcanic masses, and in which a great variety of substances are subjected in different degrees to the combined influences of heat, pressure, and aqueous solution. The main fact in relation to the origin of the metallic copper is that it is a product, not of the fusion of the trap, but of subsequent processes, by which the fissures of that rock were filled by materials regarded as of aqueous origin."[15]

IRVING ON COPPER DEPOSITS OF THE KEWEENAW SERIES.

In his memoir on the Copper-bearing Rocks of Lake Superior, published by the United States Geological Survey, the late Roland D. Irving has devoted a very interesting chapter to the occurrence of copper in formations of the Keweenaw series, which will be found invaluable to prospectors and explorers in the search for and development of copper deposits in the Lake Superior region. The information contained in the following extract will be as instructive to Canadians as to Americans:

CLASSES OF WORKABLE DEPOSITS.

"All the workable deposits of copper heretofore discovered in the Lake Superior region fall into one or other of two classes, which we may term belt

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[15] From the Canadian Naturalist and Geologist, March, 1857, pp. 3-9.

Bed deposits and transverse vein deposits.

its and transverse vein deposits. The first class includes the cuplomerates and sandstones, the cupriferous amygdaloids, and most, the so called veins carrying much epidote and coinciding with of the formation; the second class includes those veins which formation in a direction more or less nearly at right angles to No copper has ever been observed in connection with the acid the series, nor have any workable deposits been discovered in the vesicular diabase beds, except as distinctly subordinate to, and ected with, the amygdaloid deposits or epidote courses, and always with an extreme degree of alteration.

Cupriferous conglomerates and sandstones,

glomerate and sandstone deposits are simply portions of the e rocks, in all respects of the ordinary character, save that they ated with the native copper. Cupriferous deposits of this charr the most part confined to the thin conglomerate beds which tified with the ordinary diabase flows; but one cupriferous bed is known within the upper or purely detrital division of the series, and separated from the nearest trappean flow beneath it ess of many hundred feet of sandstone layers. This is the belt red sandstone and shale in which occurs the Nonesuch copper bed upine mountains. This belt has been traced from Keweenaw d river, a distance of about 150 miles; and has been found to per at a number of points in the vicinity of the Porcupine mougain on the Montreal river, the boundary line between Michigan sin.

in which the copper occurs as a cementing material.

cupriferous conglomerates and sandstones the copper occurs nting material, and as a replacer of the constituent grains, ll cases plainly of secondary origin, and a result of depoan aqueous solution. Moreover, the cementing copper itself, which is to be seen in the thin section between the grains moulding itself sharply around their contours, is plainly a replacer of still smaller constituent particles. In the Nonesuch sandstone of the Porcupine Mountain region a large of the particles of cementing copper have within them a core of It is indeed not improbable that in all cases the cementing copa deposit in the original interspaces of the fragmental particles, s a replacer.

Copper in the Calumet and Hecla mines.

thin sections of these cupriferous conglomerates the larger parphyry matrix and fragments of the felspars are found to be replaced n varying degrees, the metal in the case of the felspar fragments follow the cleavage directions. In the famous conglomerate of t and Hecla mine in the Portage Lake region the copper has not ted the matrix, but has also entered into and more or less comaced large sized pebbles and even boulders several inches to a foot diameter. Hundreds of such boulders are picked each day from f rock before it is taken to the stamps. In these boulders the replaced both the matrix and the porphyritic felspars, occurring in when the replacement has not been carried very far, often along the cleavage lines only. Pumpelly has shown that the deposition of this copper has always followed other great changes in the condition of the porphyry fragments, and notably the replacement of both matrix and felspars by chlorite and epidote; these minerals having in turn been replaced by the copper. This relation between copper, epidote and chlorite is one which exists also in the altered amygdaloids; and the source of the constituents of these minerals may be found either in the particles of amygdaloid matrix and other basic materials which not unfrequently occur in the conglomerates themselves—in the Nonesuch sandstone forming a predominating quantity—or in the overlying trappean beds, from which they may have descended along with the infiltrating carbonated waters.

SOURCE OF THE COPPER.

The cupriferous amygdaloids,

"The ordinary cupriferous amygdaloids, such as those which are so largely mined about Portage lake, are, as Pumpelly was the first to show, simply the more or less completely altered and copper-saturated upper vesicular portions of the old lava flows, and are neither independent layers, nor 'veins' parallel with the formation. The copper has been introduced into these amygdaloids during one of the later stages of a long chain of replacements, whose history has already been briefly outlined, as worked out by Pumpelly on a previous page. Several paragraphs of his descriptions may appropriately be quoted again in the present connection.

'Considerable portions of the bed have lost every semblance of an amygdaloid, and consist now of chlorite, epidote, calcite and quartz, more or less intimately associated or forming larger masses of the most indefinite shapes, and merging into each other. Sometimes portions of partially altered prehnite occur. In places, considerable masses of rich brown and green fresh prehnite filled with copper occur; but as a rule this mineral has given way to its products.

'To this process the copper-bearing beds of Portage lake—wrongly called lodes—owe their origin. Considerable portions of these beds are but partially altered amygdaloids, containing amygdules of prehnite, chlorite, calcite, or quartz, with more or less copper; other portions are in the condition described above.

'In the still amygdaloidal portions the copper was deposited in the cavities and in cleavage planes of some minerals, and replaced calcite amygdules, etc. But in the confused and highly altered parts of the bed it crystallized free where it had a chance; more generally it replaced other minerals on a considerable scale. It formed in calcite bodies those irregular, solid, branching forms that are locally known as horn-copper, often many hundred pounds in weight; in the epidote, quartz and prehnite bodies it occurs as thread and flake-like impregnations; in the foliaceous lenticular chloritic bodies it forms flakes between the cleavage planes and oblique joints, or in places—and this is more particularly true of the fissure veins which we are not now considering—it replaces the chloritic, selvage-like substance till it forms literally pseudomorphs, sometimes several hundred tons in weight.'

The copper in these deposits is not restricted to that portion of the bed which was originally vesicular, but runs from it downward irregularly into the originally compact portions, following always a great alteration of the rock. The copper however tends always to be very irregular in distribution, and even in the longest worked and most reliable amygdaloids has frequently

and the irregular distribution of copper in them.

ied for through many feet of barren rock. In this search the ll is now extensively used, the miners being guided in its use by ice of seams of calcite and epidote, and other alteration forms, followed up with the drill are often found to lead to pockets con- h copper.

The ashbed amygdaloids.

lass of amygdaloids, those of the ashbed type,—which I agree vorth in regarding as merely very highly scoriaceous and open nto whose interstices the intermingled detrital material has subse- washed—the distribution of the copper is sometimes more uni- n the ordinary cupriferous amygdaloids, so that the whole of the broken down and taken to the stamps, as is done for instance at mine.

Copper deposits of the Ontonagon region.

per deposits of the Ontonagon region have not had the study em that has of late years been devoted to those of the Keweenaw ortage lake districts; so that it is not possible to be quite so posi- statements in regard to them. The copper of this region never nsverse fissures, but either lies in irregular accumulations—often many tons in weight—associated with much epidote and calcite, along the course of diabase beds, or else occurs with more per- vein-like aggregations of epidote and calcite. The latter coincide the bearing of the formation, and commonly also with its dip, cases, as for instance in the once famous Minnesota mine, dip angle than that of the formation, which they consequently slowly depth. According to Foster and Whitney deposits like that of ota mine show another indication of a vein-like character in the kensided and generally sharply defined walls. The 'vein' at the ne is also peculiar in lying at the base of one of the great lava nmediately above a conglomerate bed, while coinciding with them ing and dip.

dent, even with our present knowledge of the deposits of the listrict, that their history has been essentially the same as that ge lake deposits In the case of that copper which occurs irregu- uted, along with epidote and calcite, throughout certain of the ds, the process of replacement has gone on irregularly because of arity of texture in the original rock. Deposits like that of the nine may have resulted from the deflection of the altering waters urse of a pre-existing but not open fissure; the 'vein' being in before, a replacement at least in large measure of original rock

Transverse copper veins on Keweenaw Point

sverse veins have been mined for copper on Keweenaw Point they are found varying in width from mere seams to 10 and even eet. For the most part however they do not exceed one to three , the expanded portions being met with where they traverse the l or otherwise open textured portions of the flows. The same veins amygdaloid and looser textured diabases are expanded and often er, will when in the more compact and massive beds, such as the greenstone, contract to mere seams without metallic contents; and the same is in large measure true of their intersections with the sandstone belts. The veins lie always very nearly at right angles to the trend of the beds which they traverse, standing always very nearly the perpendicular. Quartz, calcite and prehnite make up the common veinstone, but they are mingled with more or less of the wall rock of the vein, which frequently predominates greatly over any true veinstone. The veins are in fact for the most part not sharply defined from the surrounding rock, but consist in each case of a network of smaller seams traversing the shattered wall rock. Veins composed almost wholly of calcite are not unknown, but they are never productive of copper. The copper in these veins occurs both in smaller fragments and minute particles intimately mixed with veinstone, and again in masses many tons in weight. The larger masses frequently are found to contain within them portions of the wall rock.

pinch out in the greenstone belt.

Nearly all of the productive mines based on these transverse veins are working directly beneath the greenstone, the layer which is described in a previous chapter as constituting so prominent a feature in the geology or topography of Keweenaw Point. This position of the mines is one not due to the non-occurrence of copper elsewhere on the course of these veins, but results from the fact that further south they become buried beneath a heavy coating of drift, while to the northward they pinch out and become barren in the broad greenstone belt.

Phenomena of the transverse veins.

These veins, on account of their transverse position to the bedding of the formation, of their often slickensided walls, and from their carrying often a true veinstone, have commonly been regarded as 'true fissures.' That they are on the lines of pre-existing fissures or transverse cracks in the formation there can, I think, be no doubt; but they are not true fissure veins in the sense that the veinstone and metallic matter occupy, along with wall-rock fragments, original fissure space. I see in them simply the results of a rock alteration entirely analogous to that which has brought about the deposition of copper and its associated veinstone minerals within the cupriferous amygdaloids. They are alteration zones which traverse, instead of following the bedding, simply because the drainage of the altering waters has been given this direction by the pre-existing fissures. All of the phenomena of these veins coincide completely with this view; the common occurrence of wall rock within the vein, or rather the embracing of the wall rock masses by the vein; the replacement of wall rock by copper masses; the occurrence of wall rock within these masses; the expansion of the veins and their greater richness where traversing the more readily alterable amygdaloids and looser textured diabases; their contraction and barrenness within the compact and less readily changeable greenstone; and the coincidence of the paragenesis of the vein minerals with that of the cupriferous amygdaloids, are all facts better explicable on this view than on any other.

No striking differences in origin of the several classes of veins.

Thus the differences in origin of the several classes of copper deposits —conglomerate beds, cupriferous amygdaloids, epidote veins parallel to the bedding and 'fissure' veins transverse to it—which at first sight seem to be great, on closer inspection for the most part disappear. They are all the result of the percolation of carbonated waters, which in the lines of fissure, xtured amygdaloids, and the nearly equally open conglomerates, east resistance to their passage, and at the same time the greatest y to their altering power. This susceptibility depended partly ry openness of these different rocks, but also, in the case of the s, in the presence of a large proportion of glass basis, the most rable substance among rock constituents.

CAUSE OF PRECIPITATION OF THE COPPER.

The home or source of the copper, and the cause of arrest in veins or beds.

Theories of precipitation,

ource and the cause of the arrest of the copper which was carried altering waters are other and more different questions. Its home ly been regarded as being within the mass of the trappean flows with which it is supposed to come to the surface. Another view as originally deposited in a sulphuretted form along with the nbers of the series from which it was subsequently leached, partly e of a sulphate, but principally as a carbonate and silicate. The view which Pumpelly has elaborated[17]; to whom also is due the ving advanced the only satisfactory view as to the cause of arrest er in the places where it is now found. He has shown the exist- intimate relation between the precipitation of the copper and the n of the ferrous oxide of the augitic constituent of the basic rocks; constant as to render irresistible the conclusion that in this le is to be found the precipitating agent of the copper. To this I hat the ferrous oxide of the magnetite, and of the unindividualized he vesicular layers, has also been concerned in this re-action.

and objections to them.

this explanation of the precipitation of the copper seems satis- have too little to go upon in deciding between the two views ed to as to the source of the metal. Too few signs have been the existence of copper in the upper sandstones of the series, such expected were this its home, to allow of an easy acquiescence in view. On the other hand, the trappean rocks themselves are for rt devoid of copper, except such as is plainly secondary. Copper retted form I have however observed in the coarse gabbros of the green uralitic gabbro of Mount Bohemia, and in similar in one or two places on the north shore of Lake Superior. It is aid that copper occurs in the conglomerates and sandstones only ld have leached directly downwards from an overlying trappean with one exception the statement is undoubtedly correct. The that of the Nonesuch cupriferous sandstone, which is however a ant exception, since this rock not only has no overlying diabase, ated from the nearest trappean flow beneath it by many hundred tal material. As previously shown, this sandstone is unusual for portion of basic detritus. Its copper can only be connected with source by supposing it to have formed part of this detritus in the d condition, and afterwards to have been dissolved and re-deposited tate. This is a supposition which would seem on the whole however more violent than to regard the copper as having come from the overlying sandstones, and as having been arrested in its descent on meeting a layer so rich in basic detritus as to be able to furnish the requisite supply of precipitating agent.

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[17] Geology of Michigan, vol. I, part III, p. 43.

RULES TO GUIDE THE EXPLORER.

Rules for the explorer in rocks of the Keweenaw Series.

"From the facts and theoretical considerations thus given may be formulated a few simple rules to guide the explorer for copper in the regions traversed by the Keweenaw Series. Thus the explorer, should he be searching for transverse veins, should bear in mind that epidote, prehnite and chlorite are the favorite associates of the copper; that veins carrying a greatly predominating quantity of calcite are not likely to be cupriferous; that laumontitic veins have hitherto not proved to be sufficiently rich for exploitation; that a vein which may be very rich and wide in the amygdaloidal or other soft and easily decomposed rocks will pinch to a mere seam and become barren within the massive and more compact layers; that hence the intersection of a vein with such amygdaloidal or other soft beds should always be searched for; that the copper occurs in these veins with extreme irregularity; and finally, that a vein found traversing decomposed amygdaloid beds with the favorable veinstone, even though it show only a little copper at surface, is worthy of examination.

Transverse veins.

Cupriferous belts.

Should our explorer be looking for cupriferous belts, he should see that they are well defined; that they present evidence of much alteration such as is above indicated, and that one or more of the favorite associate minerals of the copper are present. These favorable indications, along with a more or less well-preserved amygdaloidal character to the rock, and the presence of some copper at surface, are sufficient to warrant further examination. In searching for these belts care should be taken not to be misled by the occurrence of seams of native copper without veinstone along the joint cracks of an unaltered massive diabase, and of isolated pockets of epidotic and calcitic material carrying some copper.

Sandstone and conglomerate deposits.

In the case of sandstone and conglomerate deposits the explorer is to bear in mind that thus far they have been found only where a thin seam of conglomerate is directly overlain by a trappean mass; or if away altogether from the trappean beds, only in sandstone which is very rich in basic detritus. Beyond this, there is nothing to guide him except the finding of the copper itself. Any one of the numerous conglomerate seams which from Keweenaw Point to Minnesota are everywhere interbedded with the prevailing basic flow might become cupriferous at any point along its course.[18]

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[18] The Copper-bearing Rocks of Lake Superior, pp. 419 27.

IV.

TINOLITE, ASBESTOS AND TALC.

Identity by classification and name.

the earliest records we have of the generations of the heaven , we are told that every living creature was brought unto the hat he would call them, and that he gave names to all cattle, to he air and to the beast of the field : "Whatsoever the man iving creature, that was the name thereof." The first step of æus says, is to know natural bodies, and to be able by those ted on them by nature to distinguish them from each other, and very object its proper name. "These," he wrote, "are the ll science ; this is the great alphabet of nature ; for if the name nowledge of the object is lost also ; and without these the student ain for the means to investigate the hidden treasures of nature." it may have been with the first man, all of us will agree that of things so as to name them is no simple or modest acquire- things are not within the immediate reach of human capacity," næus again. "Many have been made known to us, of which nt before us were ignorant ; many we have heard of, but know are ; and many must remain for the diligence of future ages." s is one has only to study the great Swede's own System of light of modern science. We smile at the doctrine that the ocean teems with a double offspring, a saline male and a terrene nitre, muria, natrum and alum are the fathers, and that clay, calx are the mothers of stones ; that clay is the earth of marine nd the earth of rain water. We might smile also at the theory fter remaining a long time dry and compressed is hardened into hich by resolution is often regenerated into fibrous asbestos, but y resolved is in a wonderful manner reproduced into scaly fear we know as little of the genesis of these minerals as did self. Of their exact composition and structure we know much mical analysis and the microscope have added largely to our rocks and minerals during the last fifty years. We know also onditions, changes go on within rocks almost as complex and a living organism, begetting little interchanges in the chemical and molecular arrangement of the component minerals which e entirely new qualities, or may alter completely their structural pears to the eye. Limestone, chalk and lithographic stone are almost pure carbonate of lime ; yet their natural qualities are nt, and they look as unlike as three distinct races of men. But re striking illustration in the minerals which are the subject of Actinolite, asbestos and talc are very largely made up of the same bstances, and the first and second very nearly in the same com- fourth mineral, chrysotile, is so like asbestos as to be commonly

Constituents of actinolite, asbestos, chrysotile and talc.

mistaken for it; so commonly indeed that in commerce and the arts the bulk of what is sold and used as asbestos is chrysotile, or perhaps it would be more correct to say chrysotile with adulterants of actinolite and talc. To show how closely related these four minerals are, I subjoin a table of average constituents computed from Dana:

ANALYSES OF MINERALS.

	Actinolite.	Asbestos.	Chrysotile.	Talc.
Silica	57.13	57.82	43.56	61.95
Alumina	1.15	.43	.52	.98
Ferrous oxide	6.39	5.23	1.60	1.91
Manganese oxide	.65	.66		
Magnesia	20.66	21.86	41.36	30.87
Lime	13.28	13.98		
Water	1.57	.77	13.79	4.08
Totals	100.83	100.75	100.83	99.79

Similarities and diversities in component parts and crystallization.

The composition of actinolite in this table is an average of eleven analyses, asbestos of six, chrysotile of five, and talc of forty; and the constituents of each may be therefore taken as standard. Actinolite and asbestos, it will be seen, contain two minerals which are wanting in chrysotile and talc. These are lime and manganese oxide, the former of which is nearly fourteen per cent. of the whole and the latter only little over half of one per cent. Between actinolite and asbestos also the average combinations are so nearly similar that less diversity occurs between them than between individual specimens of each other. It is only in the protoxides of iron and manganese that the differences are more than one per cent.—actinolite having 1.16 more of the ferrous oxide than asbestos, and asbestos 1.20 more of the manganese oxide than actinolite. Both indeed are but different forms of amphibole or hornblende, or that variety of it which contains little or no alumina. When the crystals of the mineral are in radiating masses or long slender prisms we call it actinolite, and when in long, fine, flexible fibres, easily separable by the fingers, we call it asbestos; but other forms are known as tremolite, nephrite, antholite, richterite, cummingtonite, dannemorite and grunerite, each of which graduates more or less towards asbestos, showing fibrous structure. Chrysotile, which is so like asbestos, is widely different in composition, having 14.26 per cent. less silica and 3.63 per cent. less ferrous oxide, but 19.4 per cent. more magnesia and 13 per cent. more water. It belongs to the serpentine group of rocks, and like all these it contains a high percentage of water. This it is which makes chrysotile less capable of resisting the action of fire than true asbestos, for when the water of crystallization is driven off by heat the fibre becomes hard and brittle. The true fibre, it is claimed, will easily stand a temperature of 2,000 to 3,000 degrees F., and on the best qualities a temperature of 5,000 degrees will produce no visible effect. Talc contains four per cent. more silica than asbestos and nine per cent. more magnesia, but not one-third as much water as chry-

these minerals it is low in alumina, and in ferrous oxide it
ame as chrysotile. It is found foliated, fibrous and massive,
f its forms it can hardly be distinguished from corresponding
olite, asbestos and serpentine.
e general observations, I pass on to notice some particulars of
erıls with which I am dealing, where they are found in Ontario,
are made of them.

ACTINOLITE.

Areas of actinolite in Hastings and Addington.

of country in the counties of Hastings and Addington, embrac-
ships of Hungerford, Elzevir, Kaladar and Grimsthorpe, is
many miles by a band of serpentine or magnesite in which are
ent intervals bodies or veins of actinolite, and perhaps also of
s serpentine occurs too, as well as fibrous hornblende, although
olite is used generally to describe fibrous or non-fibrous mineral
ractory qualities. No deep mining has yet been attempted in
he practice pursued being to sink pits to a depth of twenty-five
where the mineral outcrops at the surface, and when it cannot
out the help of costly machinery the pit is abandoned and a new
. This work is carried on for the most part by farmers on their
in the winter or whenever a favorable opportunity offers loads
are drawn to the mill at Bridgewater. This mill was built in
e owners of it have also carried on mining upon their own
t year two properties were worked in Elzevir, about three
idgewater, but not having seen these I am unable to describe
eral itself or the formation which contains it.

PROPERTIES IN ELZEVIR.

Geological formation.

ber I visited three properties about ten miles north-east of
near the line of the old Flinton road. This road follows close
nata river, and for half its way crosses and re-crosses a band of
hich traverses the country in an east-northeast and west-south-
. At lots 7 and 8 in the eleventh concession of Elzevir the
eeded by a band of conglomerate, and this in its turn by one
parallel to the gneiss. The serpentine forms a series of ridges
alleys between, running with the course of the formation. On
side it is cut by two dykes of felspar or pegmatite fifteen to
thickness, while about 200 yards towards the south parallel
The second of the dykes on the western side, which is the
dips southeast at an angle of 80°. Beyond it the serpentine
bands of red and green, and holding small starlike crystals of
Iuch of this serpentine is of a fibrous character, and several
e on the property prove the existence of one or more veins of a
ous mineral, the characteristics of which will be described farther
ity of mineral was raised on these lots several years ago and
nill at Bridgewater. They are now owned by The Standard
pany of New York, of which ex-Governor Campbell of Ohio is

Standard Asbestos Company's exploratory work.

president, and last year development work of a promising character was carried on under the management of Mr. J. E. Harrison of Bridgewater. A shaft of eleven feet square was sunk on lot 8 to a depth of forty feet, and about 475 tons of fibrous mineral raised. The vein at the surface was only four feet in width, but it widened gradually as the work of deepening proceeded until at about ten feet it was the full width of the shaft. No cross-cutting has been made to ascertain its width at the bottom, and one side of the shaft having followed the hanging wall (which is beautifully slickensided), the opposite side is in the mineral. Reddish colored bands cut across the vein horizontally at intervals of three or four feet, caused probably by infiltrations of iron through seams in the mineral, but which do not appear to have altered its character in any other respect. The quality has continued to improve with the depth, fibres at the bottom of the shaft being about three-quarters of an inch in length. In color the mineral in place is dark green, but after exposure to the air it becomes white, or a pale greenish white.

PROPERTIES IN KALADAR.

Exploratory work by a Gouverneur syndicate.

On the adjoining lot in Kaladar, 8 in the first concession, a syndicate of capitalists in Gouverneur, N. Y., who have had large experience in mining and milling talc at that place, have been doing some prospecting work. They have obtained a lease of the mining rights from the owner of the farm, Mr. D. H. Smith, and have opened several pits upon it. The formation is the same as in Elzevir, and no doubt is a continuation of the same band of serpentine. The stellar crystals of actinolite are distinctly seen in the walls of the openings, gradually thinning out on both sides. The pits however were filled with water, so that I could not observe the character of the mineral at the bottom: but I was informed by the manager of the syndicate, Mr. Whitney, that it opens on a vein twenty feet wide. Mr. Whitney claims that there are three parallel veins on this property. He has also secured for the syndicate several other good locations in Elzevir and Kaladar, and it is proposed to continue development work throughout the present year, or until the extent of mineral on the locations is fully proven.

A large outcropping on Stony creek.

I visited also lot 12 in the second concession of Kaladar, the farm of Mr. George Peebles, where there is a fine and large outcropping of actinolite. It appears to be on a continuation of the same serpentine belt, which here pursues a north-easterly course, and beside it on the west is a band of conglomerate similar to the one which crosses lot 8 in the eleventh of Elzevir. A long and high dyke of pegmatite lies parallel with the vein of actinolite on the east, but separated from it by a narrow band of serpentine. The width of the vein is about twenty five feet, and for some distance it forms the left bank of Stony creek, which here flows swiftly down through a gorge whose walls of rock are fifty feet high and almost perpendicular. No mining has been done on this property, although the situation is favorable for taking out mineral at very low cost. The discovery was made about twenty years ago by Mr. J. E. Harrison, who holds a half interest in it.

THE BRIDGEWATER MILL.

The mill at Bridgewater for grinding actinolite and other fibrous minerals was built in 1883, and for six or seven years the value of its product was about $6,000 per annum. A dispute between the owners however caused it to lie idle for four years; but their rights having at last been settled in the courts, work was resumed last year. The rock is first crushed in a breaker and then reduced to dust in a pulverizer, but not so fine as to destroy the fibre. Most of the product is shipped in a dry state, but some of it is prepared for roofing material by mixing it with tar. The proportion is eleven gallons of tar to 100 lb. of ground mineral, but pitch or asphalt may be used instead of tar. It is claimed for this roofing that it never gets hard, that heat or cold does not affect it, and that it is fire-proof. The same composition is also used for sidewalks and the foundations of buildings. Uses of actinolite.

ASBESTOS.

In offering any remarks on asbestos, one is perplexed with the doubt if the thing itself exists as the authorities have defined and described it for us. We have fibrous pyroxene, fibrous hornblende, fibrous serpentine and fibrous talc, and by one person or another each of these has been called asbestos.

DEFINITIONS OF THE MINERAL.

Sterry Hunt. Sterry Hunt wrote: "Amphibole assumes fibrous forms as in tremolite, and is often radiated as in actinolite, passing into the soft, flexible, silky variety which constitutes true asbestos or amianthus."[1]

Dana. Dana says: "Pliny supposed it a vegetable product, although good for making incombustible cloth, as he states. The amianthus of the Greeks and Latins was the same thing; the word meaning undefiled, and alluding to the ease of cleaning the cloth by throwing it into the fire. The colors vary from white to green and wood-brown. The name amianthus is now applied usually to the finer and more silky kinds. Much that is so called is chrysotile, or fibrous serpentine, it containing 12 to 14 p. c. of water."[2]

Chapman. Professor Chapman, in describing amphibole, says: "The greenish white and colorless or pale gray varieties of this mineral are usually known as tremolite; the bright green, or dark green, acicular and fibrous varieties as actinolite; and the green massive varieties, as well as those in green, brown or black, thick crystals, are commonly termed hornblende, a name applied by many authors to the species generally. A soft silky variety in fibrous masses, belonging however partly to pyroxene, is also known as asbestos or amianthus, but this variety does not appear to occur in Canada, our so-called abestos being a fibrous serpentine, containing about 12 or 14 per cent. of water."[3]

Rutley. Rutley says: "Asbestos or amianthus is a fibrous variety of pyroxene occurring in white silky fibres, which are matted together, but are easily separable. Byssolite is more compact in aggregation, the fibres are coarser as a rule and are not easily separated, the structure more resembling that of wood, while the color is usually dark green or greenish gray. It may be regarded as an iron-maganese amphibole."[4]

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[1] Systematic Mineralogy, p. 250.

[2] System of Mineralogy, sixth ed., p. 234.

[3] The Minerals and Geology of Central Canada, third ed. p. 102.

Day.

Dr. Day of Washington says: "The fibres of asbestos are short and brittle, while those of chrysotile are flexible, slightly elastic, and of great tensile strength."[5]

Ells.

Dr. Ells of the Canadian Geological Survey says: "What is known as the Quebec asbestos of commerce and the true asbestos are two distinct substances, and belong to two distinct groups of minerals. Thus asbestos proper belongs to what is known as the pyroxene or hornblende group, while that obtained from the Quebec mines belongs to the talc or serpentine group. The former is classed among the igneous rocks proper, such as syenites, granites, porphyries, etc., and embraces among other varieties augite, diallage, hornblende, etc. Some asbestiform minerals are augitic, but the greater number belong to the hornblende family, and are known by several names, such as amianthus, asbestos, byssolite, tremolite, actinolite."[6] Dr. Ells also says that among the most important of the properties of asbestos is its non-conductivity, or power of resisting the action of heat, in which respect it possesses some of the properties of wood, but does not, like wood, char or ignite under friction, no matter how long it may be applied. "This property of non-conductivity," he says, "or of resistance to fire or heat, is one of the principal reasons for its extensive application in certain lines at the present day."

Klein.

Mr. Klein, M. E., of Black Lake, Q., says: "Asbestos is a fibrous variety of serpentine, and is, chemically speaking, a hydrous silicate of magnesia. From several analyses of a number of specimens all over the world, which I had at my disposal, the percentage of silica is from a little over 40 to 40½ per cent., while magnesia is from 41½ to 43 per cent.; other more prominent admixtures were ferrous oxide and alumina in quantities of from 1 to 3 per cent., and further, traces of lime, potash, soda, chlorine and sulphuric acid. This composition is completed by water, to which we have to attach the most importance from a business point of view. This of course is not water in the form of a moisture, but water intimately associated with the silicate of magnesia. The importance of this water has been shown by the fact that good and fine asbestos fibre, may it be from the Italian variety or from the Cambrian rocks of the Eastern Townships, or the Laurentians from the north of the St. Lawrence, contains from 13½ to 14 per cent. of this water, while some very harsh and brittle specimens of asbestos have shown considerably below 12 per cent. Experiments have further shown that it is comparatively easy to dissociate a part of this water from a fine and silky specimen of asbestos fibre, and to render the same hard and brittle by heating it to a certain extent."[7]

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[4] The Study of Rocks, p. 131.

[5] Mineral Resources of the United States, 1889-90, p. 514.

[6] Asbestos, its History, Mode of Occurrence and Uses, p. 5.

[7] Journal of the General Mining Association of the Province of Quebec, vol. I. p. 145.

Donald of Montreal argues that, because the Province of Que- about 85 per cent. of the world's supply, with the balance taly, it is reasonable that these two countries should be allowed e the name of products which are known all over the world as en though they be of other composition than the mineral to logists originally applied the term, and that other minerals, if , used for similar purposes be otherwise designated." Concern- of resisting the action of fire, he says: "It is true that asbestos xcept at very high temperatures, but it is equally true that only ate degree of heat, heating to low redness in a platinum cru- ance, is required to entirely destroy the flexibility of the fibre so brittle that it may be crumbled between thumb and finger as iece of biscuit. ' In this connection one is reminded that the aid to have possessed asbestos napkins which they cleansed by , and that Charlemagne in like manner cleansed his tablecloth, t of his warrior guests. It is not improbable that these state- a large extent mythical; certainly, if true, the articles in ques- t made of asbestos, the hydrated magnesian silicate." And on uctive property of the mineral he says: "The truth is that f is a very poor non-conductor, as anyone may prove by placing ater on a sheet of asbestos cardboard and applying heat from re simply still by placing a piece of wood on a sheet of asbestos a hot stove. . . The use of asbestos in the manufacture of ng coverings for boilers, etc., is due to its fibrous texture and its The latter property gives it a decided advantage over hair and materials, which char under continued exposure to heat, while g flexibility of its fibres gives it a like decided advantage over and other fibrous but brittle mineral substances."[8] And reply- sms on his views at a later date, Prof. Donald says: "I am quite dmit that a napkin, if made of fibrous hornblende, is practically fire; my scepticism is as to these ancient napkins being made of lende. I wish to know where hornblende, having fibres so fine that they may be spun and woven, is to be found."[9] **Donald.**

Lainson Wills of Ottawa says: "The chemical qualities and perties of the respective amphibole group and serpentine group of minerals are well marked and characteristic, affording a positive enclature and classification, and allowing no arbitrary liberty as orrect mineralogical appellation. Let us by all means conserve asbestos as originally applied to the amphibole variety, and if nerically, the attributes of serpentinous and hornblendic, or sim- e-asbestos and hornblende-asbestos might be adopted. If a chem- shows a product cannot thus be classified, then we are in a new mineral, requiring investigation."[10] **Wills.**

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eering and Mining Journal, March 18, 1893.

[9] Ibid., April 1, 1893.

[10] Ibid., July 22, 1893.

Asbestos of the ancients.

This last observation of Mr. Wills is well taken, and I am not sure but we may have at least one new mineral of the fibrous variety to investigate and name. But perhaps if we knew more about the asbestos of the ancients, and the actual tests to which it was subjected by them, there might be no sufficient ground for the differences of our modern doctors. We do not believe everything that we read in Greek story, and the amianthus shroud may be only one of the many Greek myths. The asbestos of the ancients may have been nothing else than fibrous serpentine, like that of Italy or Quebec. If it was fibrous hornblende, which could be woven into shrouds and napkins, why cannot it be produced at the present day? I do not know of its being found in any country of Europe, and I do not believe that it has yet been discovered in America. Fibrous hornblende we have, but the fibre is neither long, nor silky, nor flexible. How then can it be spun into thread, or woven into cloth? It may be used as a filling with the serpentine fibre, and I have no doubt that it is so used, and to good purpose; for the quality of the goods is likely to be improved by the addition of material which further enables it to withstand the effects of heat. But there are uses of asbestos where strength is the first requirement, and in the manufacture of this class of goods all long fibre would seem to be indispensable.[11]

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[11] In 1886 a paper was read before the Society of Arts in London, Eng., by Mr. James Boyd of the United Asbestos Co., which elicited warm praise from Sir Frederick Abel, Prof. Warrington Smythe and other members of the Society. Mr. Boyd had spent much time in the asbestos mines of Italy, where his Company owned valuable properties, and he was able to give many interesting particulars of the occurrence of the mineral and the mode of mining it, as well as of the subsequent treatment. There are three distinct varieties found in that country, viz., the gray, which has a long, strong fibre, and is saponaceous to the touch; the flossy, which has a smooth, silky appearance, but is dry to the touch; and asbestos powder, which, while possessing all the heat resisting properties of the preceding, crumbles into powder when crushed. The first of these is found principally in two Alpine valleys, the Valtellina and the Valley of Aosta, and the mines are at elevations ranging from 5,000 to 8,000 feet above sea level. Mining operations are expensive, owing not only to the situation, but also to the thin and irregular nature of the seams, which makes necessary the doing of a large amount of dead-work. As the result of long observation on his own part and on that of the Company's Itálian employés, Mr. Boyd presented in his paper the following conclusions:

"1. That asbestos of good quality is only to be found in the serpentine formation. A fine seam of asbestos was found four years ago in a quartz formation which seemed to upset this conclusion, but it proved just as we suspected, that the quartz was only superficial, and before six feet of rock had been blasted away the serpentine began to crop through.

"2. That if asbestos be found on the face of a rock exposed either to the south or west, the product is generally fairly abundant and of good quality. If exposed to the east, there is fine quality but very small quantity, whilst if exposed to the north the quantity is plentiful but dry and hard, and on entering into the rock all traces of it are lost."

Another statement made by Mr. Boyd, which may be useful to prospectors, relates to the signs of the mineral where there is no proper exposure of it. "When asbestos is first found in any new place, generally the only superficial indication is that the cracks in the rocks are filled with a white powdery substance. When the surface is broken up this usually changes into a leathery-looking substance, and entering still further the true asbestos fibre may be found." But sometimes even in Italy the practice of "salting" is resorted to, which consists in "driving in fine asbestos fibre into the cracks of the rock, and trying to make it look like real formation." Mr. Boyd appears to think that this is a peculiarly American practice, and he has also discovered that Canadian fibre imported from America in the carded state by his firm was found to be a mixture of asbestos and cotton. Like the chairman of his Company—who stated in the discussion upon the paper that the Italian asbestos was superior to the Canadian in every respect, especially in its capability of being woven into cloth—Mr. Boyd expressed a strong and natural preference for the article produced from his Company's mines. "Each have their advocates and partisans," he said, "but I do not consider the present a fitting occasion to deal with this question, and I therefore limit myself to saying that whilst for certain uses the one may be as suitable as the other, it is not so in all cases. As an examination of the samples will show, the Italian is long and strong in its fibre, and is saponaceous to the touch, whilst the Canadian is short, and to the touch is as dry as chalk; and therefore it seems to me that the properties of Italian indicate it as better suited for the engineer's use, especially in the form of packing or jointing." Mr Boyd confessed that with the formation and working of Canadian asbestos he had no practical experience, and that his remarks were based upon data furnished by Mr. Irwin of the Anglo-Cana-

THE SOURCES OF SUPPLY.

Mines of Quebec and Italy.

urces of supply are not numerous, and at present they are almost nfined to Quebec and Italy. The Quebec mines at Thetford and e, in the Eastern Townships, yield an excellent article which finds in Great Britain and the United States. About $3,500,000 are the industry, which employs about 2,000 men. In 1880 the out- mines was 380 tons, valued at $24,700; but in 1890 this was o 9,860 tons, valued at $1,200,240. The following table, showing rison of Canadian with Italian abestos, is taken from a paper by ıld, read at a meeting of the Quebec Mining Association;[12] but for mparison I have added the average computed from Dana:

Analyses of Italian and Quebec asbestos.

Constituents.	Italian.	Broughton.	Templeton.	Dana.
ca	40.30	40.57	40.52	43.56
gnesia	43.37	41.50	42.05	41.36
rous oxide	.87	2.81	1.97	1.60
umina	2.27	.90	2.10	.52
ter	13.72	13.55	13.46	13.79
Total	100.53	99.33	100.10	100.83

ief difference is that the Quebec asbestos is higher in iron, but lumina, than the Italian; and compared with Dana's average it is ent. lower in silica, but higher in ferrous oxide and alumina.

Ontario samples.

tario fine samples are sometimes shown by prospectors, but most of elieved to have been brought from Quebec. There is however one ation in the township of Marmora, upon which a little work has by the present owners, the North American Stone and Asbestos of New York. It is the chrysotile variety, and the fibres are very exceeding one-third of an inch. Possibly longer fibre may be found vein is properly opened. Another location I have described already, lots 7 and 8 in the eleventh concession of Elzevir, owned by ard Asbestos Company. But I hesitate to call the mineral asbes- ink it might puzzle the doctors to find the right classification, ly they may have to get a new name for it. I have submitted a Prof. Coleman, of the School of Practical Science, who has fur-

Mineral of the Standard Asbestos Company.

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os Company. Mr. Irwin himself at a meeting of the Mining Association of pril, 1891, stated that there is very little difference between the Canadian and tos as to their composition, but there is a very great difference in their forma- Italian asbestos is exceedingly long in fibre, but it is in such a shape that it is ssible to handle it properly with machinery, while Canadian asbestos costs so manipulate, and allows it to be placed in the market in its manufactured shape at will enable it to compete with any other asbestos material." And Prof. marking upon the attempts which had been made to decry the Canadian article, dice users by the statement that chemical analysis showed the latter to be inferior ı, was able to show by analysis that the "Canadian fibre is in no wise inferior to rival." As to harshness, he pointed out that it was due to a lower percentage In fibre of very fine quality from Black Lake, analysis showed 14.38 per cent. ilst a harsh-fibred sample gave only 11.70 per cent." See Journal of the Society il 16, 1886, and Journal of the General Mining Association of Quebec, vol. I,

ıal of the Association, vol. v, p. 27.

nished me with an analysis. But as for the name, he is discreet and describes it by the phrase "asbestiform mineral." That is good so far, but doubtless the Professor will follow it farther and find a name or make one[13] The analysis shows it to consist of 61.82 silica, 23.98 magnesia, 6.55 ferrous oxide, 1.63 lime, 1.12 alumina, and 5.45 water. Compared with the Dana average of hornblende asbestos, it has .4 per cent. more silica, 2.12 more of magnesia, 1.32 of ferrous oxide, 4.68 of water, and .69 of alumina; but 12.35 less lime and no manganese oxide. Compared with the average of serpentine abestos, it has 18.26 more silica, 4.95 of ferrous oxide, and .60 of alumina; but 17.38 less of magnesia, and 8.34 of water, with lime additional. Compared with the average of talc it has almost exactly the same proportion of silica and alumina, but 4.64 more of ferrous oxide, and 1.37 of water, with lime additional. The fact that calcite is found mixed with the serpentine which forms the walls of the vein will doubtless account for the presence of lime in the mineral. Some of the fibre is nearly an inch long, and is white and strong, but harsh to the touch. The crystals however are so crossed and interwoven that it will be difficult to separate the fibre from the matrix without a large percentage of loss; it is large in Quebec, where in crushing with stone the long and most valuable fibre is partially destroyed; but a suitable treatment may be found. A shipment of 100 tons has been made to the Company's mill at Elizabeth, N.J., to be tested by a new plant which has been put in for the purpose. A smaller shipment has also been made to one of the talc mills at Gouverneur.

Production of asbestos in the United States.

In the United States the production of asbestos has shown a constant decrease since 1882. The product of that year was 1,200 tons, but in 1885 it fell to 300 tons, and in 1889 the only asbestos mined in the country was 30 tons raised in California. In 1892 it had increased to 104 tons, whereof California again produced 30 tons. This is a curious commentary on the accounts of mineral wealth which occasionally find their way into scientific periodicals. A wonderful discovery of asbestos in California was reported in the Journal of the Society of Arts five years ago. "The vein is about twenty-five feet in thickness, and has been proved to extend for a distance of 1,500 feet, and is traceable for nearly three-quarters of a mile by croppings that occasionally come to the surface. Unlike many other asbestos deposits, this vein is almost unmixed with hornblende and tremolite. The fibres are long, silky and of a beautiful pearly lustre. The fibres are as tough as flax, and are capable of being spun into a fine thread. . . In the same vein there appears to be an inexhaustible quantity of ordinary abestos, such as is used for covering steam pipes, etc. The true amianthus is found in veins from one to four feet in thickness, and can be pulled out with the naked hands in tufts upwards of three feet in length."[14] And yet with this wonderful vein to draw upon, the manufacturers of asbestos goods in the United States continue to get almost all their raw material from the Province of Quebec. But this is not the only instance in which British scientific periodicals have been used to boom properties in the United States and elsewhere. It is now said that development work is being carried on in Wyoming, where veins and pockets are reported to be numerons, varying in width from a few inches to four feet. Some of the fibres too are claimed to be over forty inches in length.[15]

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[13] Dr. Coleman has made a further study of this mineral, which he describes as consisting chiefly of irregular bundles of a strong, fibrous mineral resembling chrysotile mixed with a dull green one like serpentine, the two passing into one another. "The serpentine mineral has evidently been formed from enstatite, since it encloses at one or two places remnants of that mineral on which it has encroached. Small amounts of pale green fibrous talc are mixed with the tough fibrous mineral, and the talc sometimes occurs in small masses by itself. In addition, one finds portions of carbonates, partly effervescing with cold dilute acid, and hence calcite; partly dolomite, or perhaps a related carbonate." And commenting upon the chemical composition of the mineral he says: "The results of the analyses correspond quite closely with the composition of enstatite, supposing its constituents to be rearranged and hydrated. They come less close to the orthorhombic amphiboles, such as anthrophyllite, showing too little silica and iron, and too much magnesia and water; and they differ widely from chrysotile, having far too much silica and far too little combined water and magnesia. In physical characters however the resemblance between this fibrous mineral and chrysotile is very close. They are indistinguishable under the microscope, having the same silky fibres and parallel or almost parallel extinction. . . . It seems to correspond most nearly in chemical composition to some of the fibrous forms of monoclinic amphibole, *e. g.* antholite or kuppforite. The analyses given of the latter mineral differ but little from those made by the writer; but the last edition of Dana's Mineralogy drops the name entirely, and gives antholite only a very brief reference. Probably if it is to be referred to any species beyond the broad one of 'fibrous amphibole containing little or no alumina,' the name antholite is the most appropriate. The amount of combined water, which varies however in different samples, seems the only objection to such a reference."

MANUFACTURE OF ASBESTOS GOODS.

British and American manufactures.

The manufacture of asbestos goods has developed into an important industry within the last ten years, and large establishments are employed in Great Britain and the United States. It might be interesting to describe the process by which the raw material is rolled and stirred and boiled to separate the fibre from its matrix, and how the short and long fibres are sorted; but this must be passed over. The goods into which the fibre is made up are various, and of important uses. Among these are building and lining papers, waterproof sheetings, fireproof papers, steam packing, steam pump and boiler coverings, firemen's clothing, blacksmiths' aprons, theatre curtains, lamp wicks, etc., for all of which it combines in a high degree the qualities of durability and safety. One factory at Erie, Pennsylvania, consumes 80 tons of asbestos per day.

TALC.

Varieties of talc.

I come now to talc, of which there are several varieties; but the principal ones are the fibrous, the foliated and the massive. These three are found in Ontario, but the largest known veins are in the counties of Hastings and Addington. Massive talc or steatite occurs in various parts of Kaladar and Elzevir, and no doubt the fibrous is found there also. The foliated has been discovered in Grimsthorpe, where there are some veins of large size. Talc has also been found in East Algoma, near the Sault branch of the Canadian Pacific Railway.

PROPERTIES IN ELZEVIR AND KALADAR.

Mr. D. J. Whitney of Gouverneur, N.Y., who carried on an extensive marble business in that place for twenty-five years, and who five years ago opened up marble properties at Madoc, is now interesting himself in develop-

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[14] Journal of the Society of Arts, December 21, 1888.

[15] Mineral Industries of the United States, 11th Census, p. 730.

The talc industry at Gouverneur, New York.

ing fibrous talc properties in the townships of Elzevir and Kaladar. In the course of a conversation he gave me many interesting particulars of the talc industry as carried on at Gouverneur, and outlined a project on the part of himself and associates to utilize properties recently acquired by them in the townships above named. Until a short time ago there were six firms or companies engaged in the business at Gouverneur, but four of these have sold their interests to a syndicate composed principally of New York Central men, including William Walter Webb and Chauncey Depew. It is also believed that the Vanderbilts hold a large block of the stock. The price paid for the properties was about $1,000,000, but the syndicate has organized with a capital of $2,000,000 preferred and $3,000,000 ordinary stock—the latter to get no share of earnings until the former has been paid ten per cent. Since this syndicate has entered into possession, the New York Central has secured control of the Rome, Watertown and Ogdensburg road, and branches have been built to all the mines and mills, thus greatly facilitating the working of the mines, but at the cost of displacing $100,000 of labor for teaming every year. The two other concerns refused to accept the terms offered them, and to the extent of their ability to compete with the stronger corporation, monopoly is held in check.

The rock formations at Gouverneur are similar to those of Elzevir and Kaladar, but as they are extensively covered with drift the task of prospecting them is one of much greater difficulty. Rocky ranges outcrop in places, but exploring has sometimes to be carried on by pits and cross-cuttings through the drift. As a consequence, when mineral is discovered and a shaft sunk upon it, tunnels are carried on for long distances—from a quarter to half a mile Some of the shafts have been put down to a depth of 300 feet or over, but it does not appear that even at this depth bottom has been reached.

The mineral occurs in large pockets or lenses, which thin out at the edges to the vanishing point, but by following on the show new bodies of similar form are almost always discovered. It is either soapstone or talc, some portions of which are slightly fibrous and nearly all of it white; but according to Mr. Whitney none of it contains the long, fibrous crystals which constitute the chief portion of the Ontario mineral.

The rock is ground either in a cyclone pulverizer, or in cylinders holding flint nodules, which by attrition reduce a charge of 1,500 lb. to the consistence of flour in a few hours.

Uses of the mineral.

The foliated talc, which is found in some places, is in little request, but it is quite suitable as filling for wall paper. The fibrous and non-fibrous or massive varieties are about equally valuable as filling for printing paper, to which it gives weight and strength, especially the fibrous material. Formerly French clay was chiefly used for this purpose, but not more than thirty per cent. of it is retained in the pulp, whereas seventy-five or eighty per cent. of the talc is so retained. The foliated talc, no matter how finely it may be

aains its scalelike form, and it is found that printing paper con-
es off in the press and fills up the face of the type, so that a clear
nnot be got.[16]

d talc is used as an adulterant in many ways, such as in the
of paint and asbestos, and sometimes it is even added to flour;
case of all other adulterants, the users of it are careful to con-
One asbestos manufacturing concern receives three or four car
of ground fibrous talc from the Gouverneur mills, and no doubt
he production of asbestos goods. Mr. Whitney also says that
ns per week of the finer grade is shipped to Canada as French
to the paper mills; but this statement does not appear to be
the Government trade tables.[17]

s mineral of Ontario may be utilized for all the purposes of the
rticle, but the long fibre will be much more valuable for the
. By sifting, the several grades may be easily separated—the
to be sold to the paper, and the coarser or more fibrous to the
ufacturers. The Gouverneur product is in part exported to
the Canadian will have an advantage in furnishing a better
ossibly in securing cheaper rates of delivery to the seaboard. It
favor in the United States, owing to its wider range of qualities.
oncerns which have sold out to the New York Central syndicate,
r. Whitney and his brother, purpose to engage in the industry
They have been taking up properties during the past summer,
velopment work has already been done upon them, especially
e first concession of Kaladar, adjoining the property of the
estos Company in Elzevir, but they are anxious to prove that
procurable in sufficient quantity before undertaking the erec-
o treat it. A plant of suitable capacity will cost about $100,000,
careful not to go into so large an undertaking before knowing
depend on the source of supply of the raw material. Fibrous
also valuable for the same purposes as talc, and Mr. Whitney
there are large bodies of it in the district, as well as talc and

A New York syndicate exploring in Ontario.

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s section of the Report was put in type the Berlin School Supply Company
use for talc, viz., as material for the manufacture of school crayons. A suit-
this purpose is obtained in the eastern part of the Province, and when cut
onvenient size and form it is a superior crayon for the blackboard. It makes a
on board or slate, does not easily break or crumble into dust, and will out-
n of the crayons in common use in the schools. It is being used for the
o in North Carolina.

rity of the Grimsthorpe foliated talc is that it contains nickel; but it has not
red that this metal is present in workable quantity. The following analysis
the property of the Kent Brothers, Kingston, has been furnished to the
Nicol, of the Kingston Mining School:

ca	62.95
rous oxide	2.57
mina	.85
gnesia	27.87
kel oxide	.17
ter	4.75
Total	99.16

THE TALC BELT OF NEW YORK.

Growth of the talc industry of New York State.

In a paper on the Talc Industry of the Gouverneur district, contributed by Axel Sahlin, M.E., of New York, to the Schuylkill Valley meeting of the American Institute of Mining Engineers in October, 1892, that authority describes the talc belt as having a length of eight miles by a width of one mile. "Since 1879," he says, "ten distinct mines have been opened, and some of these have reached a depth of 400 feet or more on the slope. The present output from these ten mines amounts, according to a close estimate, to 51,000 tons per annum, which figure however could be readily doubled if the reducing mills had the capacity to handle the larger quantity. The cost of mining varies from 60 cents to $1.25 per ton, to which must be added the royalty charged by the land owners, amounting to from 50 cents to $1.00 per ton of talc raised. The transportation of the rock to the mills by wagon or sleigh, over wretched country roads, costs from $1.35 to $1.50 per ton. The total cost of talc rock deposited at the different mills therefore varies from $2.25 to $3.75 per ton. . . About thirteen years ago the first talc mill was started on a modest scale at Gouverneur. Now eight efficient mills produce yearly 50,000 tons of talc, all of which so far has found ready sale without even being advertised. . . As yet," he concludes, "the talc industry is in its infancy, and hardly known beyond a few localities. When once the fibrous mineral pulp shall have become familiar to the paper trade of the world, it will not be the want of a market, but the scarcity of talc that will regulate and limit the development of the peculiar industry of Gouverneur." [18]

With such a promise for the talc industry in a small district of the State of New York, is it not worthy also of receiving a measure of attention in Ontario, where the raw material is believed to exist over a much larger area and in far greater quantity? To know the names of minerals has its value, and our doctors and professors cannot study names too carefully. But what the country most cares for is the minerals themselves, and the best way to win them and convert them from a mere natural resource or possession into tangible and potential wealth.

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[18] Trans. Am. Inst. Mining Engineers, vol. XXI, pp. 585-7.

V.

FIED BRICK FOR STREET PAVEMENTS.

Roadways of Europe and America.

ı said that the condition of a country's highways is the measure s, yet in this America of ours, where there are many other social anomalies, we have a high degree of civilization existing conly with very bad roads. The common country road of this s inferior to the ordinary road of Great Britain or of almost any of of continental Europe as are the bridlepaths and mud-filled lanes ur own highways. There is a reason for everything, and we may npensating advantages in the absence of those military considera-nake good roads a matter of prime importance to the nations of t the loss to the country at large, and particularly to the farmer, oad condition of our country roads, which amounts at certain e year to absolute impassability, can hardly be estimated.

d roads are to the rural population, good streets are to the owns and cities, but in a higher degree. They are the arteries ch flows the tide of urban life, and it is of the very first hat they be made of suitable material and properly constructed.

The problem of greatest return for least outlay.

em of life is how to get the greatest possible return for the outlay; and this is true in the realm of mechanics as well as in e. The drawing of a load along a city street is an example of re of force. The motive power is the horse or other animal, the moved is the vehicle and its contents, and the roadway supplies which the motion takes place. The energy exerted by the horse the work of starting the load and keeping it in motion, and the overcoming of what may be called the internal friction of z., the pressure of the axles on the hubs, as well as the inertia self and the resistance offered to the forward motion of the pavement. In proportion to the size and number of the obstacles the pavement—in other words, in proportion to its roughness—fficulty of moving the load and the amount of resulting wear and ovious that this wear and tear will not fall upon the pavement eavier the task, the greater the strain upon the motive power, . Extra exertion will make him prematurely old and reduce he vehicle, too, comes in for its share. Tires are worn out, spokes broken, bolts are shaken loose, and the life of the vehicle as horse is shortened. The effects of the friction are seen in es, worn harness and broken wagons, and not alone in ruts and avement. Indeed, if a perfectly indestructible material could ch to construct our roadways, even at moderate cost, it might

Cost of wear and tear.

be found that such a material would be extremely expensive, were it to present a surface of unusual roughness. From the fact however that the adverse effect upon horses and vehicles is distributed over a large number of private individuals, it is very difficult to estimate this factor in any particular case, or relatively as to the various kinds of pavement. The cost of pavements themselves can be calculated to the last cent, but only an approximation can be made to the expense entailed by wear and tear on horses and wagons. The former is generally defrayed out of the public purse, while the latter falls upon individuals; hence cheapness and durability are usually the particulars most prominently considered when a new pavement is in contemplation. It is plain that the ratio of effect on horses and vehicles must be very much larger in the case of the rougher pavements, such as those made of wooden blocks, granite, and even macadam, than in that of asphalt or brick, which present a surface of so much greater smoothness. Other things being equal, the smoother the pavement the better it is. The question of wear upon horses and carriages in relation to the various kinds of pavement has probably not yet received the attention which it deserves, although it is a very important factor in determining the superiority of one sort over another.

The axiom of good pavements.

THE QUALITY OF ROAD MATERIALS.

Materials of road-making

To the maker of roads and streets a wide choice of materials is open; and accordingly we find him making his selection from the mineral, vegetable and even the animal kingdom. In some of the southern States, for instance, the shells of the oyster are pulverized and spread out in a glistening pavement; and wood of various sorts and in many forms invites use by its cheapness and adaptability. The corduroy of the bush settlements, whose spring-breaking joltiness is preferable only to the mud of the swamps through which it is laid; the plank roads, once common in certain parts of rural Ontario; the cedar blocks of our towns and cities, not to speak of the cubes of real mahogany with which the fastidious rulers of Paris are now said to be ornamenting the streets of that luxurious city at a cost of £2 per square yard,—all testify to the utility of wood for paving purposes.

in rural districts,

But it is naturally to the mineral constituents of the earth's crust, either in raw or manufactured form, that the road builder looks when it is determined that art must be called to the aid of nature. The mud road of the country is tolerable, even comfortable, in summer when the dust does not ride on the wings of the wind; but when the spring or fall rains have converted the clay or soil into a glutinous mass of varying depth, or when the pathmaster has just finished laying on his annual contribution of loose gravel or soft earth, travel becomes difficult and hauling of heavy loads impossible. Gravel roads, such as are found in some parts of western Ontario, when well made and kept in repair afford an agreeable contrast to the ordinary mud roads, and really add largely to the value of the farms in front of which they pass. Broken stone is a step in advance of round gravel, but in this country Macadam numbers few followers outside of towns and cities, and in the latter, macadamized surfaces, though suitable for light traffic, ıto disfavor because of their uncleanliness and the expense nstant repairs.

and in the cities and towns. reets, stone or granite sets, asphalt and vitrified brick are all ch one of these several materials possesses excellent qualities rposes. As compared with wooden blocks, each of them is preost every particular, except in the important one of cost.

Cedar blocks. tretches of cedar block pavement which have been laid down in ronto, for instance, cannot fairly be said to have been successful. idential streets, where the butcher, the baker, the grocer and the ide the bulk of travel, cedar blocks do tolerably well. They are to lay, repairs are easily made, and where the traffic is light an even surface for a considerable length of time. But where e numerous and travel constant, cedar blocks are altogether out ė edges soon wear off, leaving each separate block of a rounded, obular form, and producing a surface comparable in roughness vamp corduroy. The porous nature of the blocks permits them ery large portion of the liquid filth which falls on the street, d to the dirt, droppings, etc., which lodge in the hollows between ks and which ordinary street cleaning is powerless to remove, of decaying, germ-breeding matter not only offensive to the ll, but injurious to the public health. The life of a cedar block ies somewhat in proportion to the travel over it, but on heavy in cities like Toronto it does not exceed four or five years. is light another source of decay is in the blocks not being kept ist, but being alternately wet and dry they succumb to rot ı as they would have done to the wear and tear of heavy traffic.

Granite. ıualities of a granite pavement are many. It is not indestructadamant compared with wooden blocks; and in a list of all the l for street paving, so far as time and experience have yet dislative durability, the first place would probably belong of right Possessing this prime requisite for paving purposes—high powers ear—and being comparatively unobjectionable from a sanitary , were granite smooth and inexpensive, one would probably look no further for a paving material. There are vast stores of archæan formations of our own Province, much of it convenient by water or rail; and in places where dray and freight traffic severe tax upon the resisting qualities of a pavement, granite always remain in use notwithstanding its comparatively high pensiveness of granite sets is due largely to the amount of labor properly dress and shape them, an item which cannot be avoided not offset even by our comparative nearness to the places of ranite pavement affords a better foothold for horses, especially in weather, than asphalt, but it is not so smooth, and its adverse oth horses and vehicles is certainly very much greater.

Asphalt. avement is exquisitely smooth. It offers less resistance to the hicles than any other pavement known, and is very easily swept ı. From a sanitary point of view it is entirely unobjectionable, and when made of pure lake asphalt it is durable. Carriages and wagons make little or no noise passing over it, but the clatter of the horses' hoofs is not inconsiderable. The drawbacks to asphalt pavement are its very high cost, its slipperiness, especially when covered with a coating of ice or sleet, and the injury and expense attendant upon disturbing it for repairs to sewers, gas pipes, etc. The asphalt pavement first laid down in the city of Toronto was on that part of Bay street which lies south of King, and after five years' existence it is still in perfect condition, while on many other streets pavements since put down are showing numerous cracks which are rapidly becoming fissures, and other symptoms of wear. There is also a difficulty in making repairs to asphalt pavement, as it is no easy task to fuse the new material with the old, and if this is imperfectly done a weak spot is left to become a centre of disintegration. Another drawback of minor importance is the fact that in cold weather an asphalt pavement cannot well be sprinkled with water to keep down the dust, as a thin coating of ice is immediately formed, troublesome and even dangerous to horses. The life of an asphalt pavement is variously stated, some placing it at from seven to ten years where the traffic is heavy, and from sixteen to twenty years where it is light. There has not as yet been sufficient experience with asphalt in our own climate to judge with accuracy how long it may be expected to last under ordinary conditions, but the figures given above are probably not far from the mark. Very much however, as is evident from the experience of Toronto, depends upon the quality of the material and work.

Brick. A brick pavement made of good material, properly laid, is almost everything that a pavement should be. It is smooth, ranking in this respect next to asphalt, and consequently offers a minimum amount of resistance to the passage of traffic, and inflicts a minimum of wear and tear upon horses and vehicles. It has the advantage over asphalt that, while it is smooth, the small spaces between the bricks afford a foothold for horses and prevent their slipping. So far as sanitation is concerned, it leaves little to be desired. It can be swept, cleaned and washed with ease, ranking in this respect next to asphalt, and far superior to granite or wood. It has none of the absorptive properties of wood, being nearly as impervious as asphalt and granite, and consequently escapes the odium which attaches to wood pavements of harboring filth and decaying organic matter. No pavement is noiseless, but in this particular brick comes next to asphalt and excels granite, being quite devoid of the "bumpiness" which characterizes the latter. It is easily laid and easily taken up when underground repairs are to be made, being almost as convenient to handle as wooden blocks and quite as much so as granite. The question of the durability of brick pavements is one that has been much discussed, but although American experience in this line has been largely confined to the last ten or twelve years and a final judgment cannot therefore be pronounced, it is everywhere the opinion that in point of durability brick is not excelled by any other material. The first streets paved with brick in America are at Charleston, W. Va., and Bloomington, Ill., where the pavement has been down about twenty years. In the former place it has given "entire satisfaction," and in the latter the verdict is equally favorable. It "gives universal satisfaction, and stands heavy traffic, showing no signs of wear." At Wheeling, W.Va., where there are twenty miles of brick pavement, the first was laid in 1883. There, too, the city authorities are emphatic in its praise as being economical, durable, sanitary and smooth.

BRICK FOR BUILDINGS AND PAVEMENTS.

Early use of brick for structural purposes.

As a building material, brick came very early into use. At the dawn of history we find it employed in the erection of large and important structures which were intended to be a lasting memorial of those who built them. It is narrated in the oldest and most trustworthy record of the primal days of man that "The whole earth was of one language and of one speech. And it came to pass, as they journeyed from the east, that they found a plain in the land of Shinar; and they dwelt there. And they said one to another Go to, let us make brick and burn them throughly. And they had brick for stone, and slime had they for mortar. And they said Go to, let us build us a city and a tower whose top may reach unto heaven; and let us make us a name, lest we be scattered abroad upon the face of the whole earth."[1]

Brick of Babel.

It is evident that the bricks spoken of here were not of the ordinary sun-dried variety common in the East, which were without doubt the first kind made and well known to these early builders, but kiln-burned brick of a superior quality. They were bricks "burned to a burning" employed in the erection of a building which was to be of great height and durability; and the emphasis placed upon the thoroughness of the burning shows that experience had already proven the value of long exposure to great heat in improving the quality of brick, both as regards its crushing strain and its power of resisting the elements. Indeed, from a careful reading of this passage, one might be almost inclined to claim that we have here the first mention of vitrified brick. We know also that at a later date the lives of the children of Israel in Egypt were made "bitter with hard bondage, in mortar and in brick," and that when their taskmasters withdrew the allowance of straw which they were accustomed to mingle with their clay, they were nevertheless required to furnish the same tale of bricks as before. It is probable that the Israelites were set to work upon the alluvial deposits of the Nile, whose sandy loams were wanting in tenacity and plasticity and required the admixture of some such material as chopped straw to enable the bricks to withstand the necessary handling before being dried. The treasure cities upon which the hapless Hebrews were engaged, Pithom and Raamses, have yielded their secrets to the archæologist, and bricks containing chopped straw or stubble have been unearthed from the courses where in all probability they were laid by the compatriots of Moses and Aaron. These were most probably sun-dried brick, such as would soon crumble to pieces in our climate, but which under the rainless sky and eternal sunshine of Egypt have been preserved until now in as good condition as when laid. Hard-burned bricks have been found among the ruins of many of the buried cities of the East. At Khorsabad, a little modern village on the Tigris, on the site of the great palace built by King

Brick of the treasure cities of Egypt.

Brick of buried cities of the East.

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[1] Genesis xi: 1-4.

Sargon, a pavement has been uncovered of artificially burned bricks, so hard that when struck they rang like a bell; as well as arched covers for sewers formed of radiating bricks accurately moulded, and glazed wall tiles in profusion.

PAVING BRICK IN MODERN TOWNS AND CITIES.

Introduction of paving brick in America.

But though sun-dried and kiln-baked brick were among the earliest of architectural materials, the use of brick for paving purposes is of comparatively modern origin. Streets in some towns of continental Europe and England have been laid with brick for many years; but it is in the United States and within the last ten years that the reign of paving brick may be said to have begun. To show the extent of the favor to which it has already attained, it has only to be said that in September 1893 there were in the United States no less than 139 manufacturing establishments in which street brick were made, and 311 towns and cities in which brick pavements were in use. Some of these manufactories are of great size, turning out as many as sixty millions of brick per year, and the industry is still rapidly expanding. Nor is the use of paving brick confined wholly to the smaller class of towns or cities. Among the large places which are giving it a trial are Boston, Detroit, Washington, Minneapolis, St. Paul, Buffalo, Rochester, Cincinnati, Cleveland, Kansas City, Atlanta, Louisville, Pittsburg, Philadelphia and Chicago. A recent list shows that in the State of Michigan eight cities have given in their adhesion to brick, in West Virginia nine, in New York sixteen, in Indiana seventeen, in Iowa twenty, in Pennsylvania thirty-nine, in Illinois forty-four, and in Ohio fifty-six.

Testimony in favor of the material

The testimony given by these places is almost unanimous in favor of brick as a paving material. Judge E. H. Thayer of Clinton, Iowa, president of the Iowa Road Improvement Association and editor of the Clinton Daily Age, says in a letter to the Bureau, dated 22nd March, 1894: "Vitrified brick for street paving is in general use in the West. For heavy traffic there can be no superior, and it answers the purpose fully as well as granite. In my opinion, it is the paving of the future of this entire country." Charles P. Chase, C.E., also of Clinton, and author of an excellent handbook entitled Brick Pavement, published in 1891, says under date of 6th April, 1894: "If the best quality of brick is used and the work well done, I have no doubt but that it is the cheapest and most durable pavement for the money that can now be obtained. Our cities are disgusted with wooden pavements when compared with brick; and granite and asphaltum are too expensive as a general thing. The best brick well laid will make a pavement as good as granite, except on streets where the heaviest traffic is carried on. It is easily laid or removed for repairs, is clean and sweet as compared with wood, and not as slippery as asphaltum or granite, and not as noisy as granite. . . Our people here, and the same is true of other cities in this part of the United States, are pleased with the pavement, and the city is unable to furnish it as fast as the people call for it."

from Iowa,

from Illinois,

In Chicago, if anywhere, the conditions of travel and traffic are sufficiently severe to put any kind of paving material to the test. In a letter dated 27th March, 1894, Mr. A. W. Cooke, Chief

Engineer, Department of Public Works, Chicago, says: "Vitrified brick as a material for roadway paving has been extensively used in the United States for more than twenty years, principally in the cities and towns in the western central States, and whenever properly used has never failed to give satisfaction. . . As compared with asphalt, granite and cedar block pavement, vitrified brick ranks second as to first cost; first as to cost of maintenance; first as to ease with which it can be repaired; first as to durability under traffic; third as to noiselessness; second as to freedom from dust; first as to freedom from decay; second as to freedom from absorption; first with granite as to foothold for horses; and second as to ease of traction. In a sanitary point of view it is without a superior, and excepting asphalt, without an equal." In view of the great size of Chicago, the immensity of the traffic carried on there, and the wide experience which that city must necessarily have had with the various kinds of pavements, the certificate of Chief Engineer Cooke is high praise indeed. The city engineer of Memphis, Tennessee, states that the pavements in that city are principally granite, limestone, gravel, macadam and vitrified brick. Of the last he says: "It has been in use in the city of Memphis under medium heavy traffic since April, 1889, during which time the city has not spent one dollar for repairs except where the pavement was torn up for repairs of gas and water pipes. I believe that the brick pavement is destined to supersede the various pavements heretofore used, and that it will be generally accepted in many cities except for very heavy traffic. It has given general satisfaction in Memphis as a sanitary pavement, being easily and economically cleaned. It is comparatively free from noise, and does not tax the nervous system like the stone and granite pavements. The surface is smooth, pleasing to the eye and affords a fair foot-hold for horses."[2] Many other similar expressions of opinion could be quoted. The sincerest testimony however which can be given is the rapidity with which the cities in all parts of the United States are adopting the new pavement. Mr. C. M. Rickard, City Engineer, Springfield, Ill., says: "Street paving was begun in this city in 1883, and carried on to such an extent that in 1887 about twenty miles of streets were paved. The material used was hemlock boards and white cedar blocks, without tar. The life of this pavement laid on the hemlock boards was about seven years. . . We have now begun repaving, and in the next few years all the old block pavement will have been replaced with brick. . . During the year 1893 three miles of brick streets were paved at an average cost of $1.26 per square yard. During the coming season there will probably be about four or five miles of streets repaved."[3] There are sixty miles of it in Philadelphia and Germantown, eighty-five miles in Columbus, Ohio, ten miles in Indianapolis and five in Cincinnati, while New York, which has experimented with every variety of street material, is now paving Broadway south from Central Park with brick. The city engineer of Washington, says: "Owing to their more enduring qualities, we are paving all alleys with vitrified brick and repaving the gutters of streets paved with asphalt with them, as they have

from Tennessee,

and elsewhere.

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[2] Paving and Municipal Engineering, February, 1894, p. 55. [3] *Ib.* p. 79.

better wearing qualities, and are not affected by water or uric acid from horses as is asphalt, and most of the new pavement is being laid with brick." The cities of the very first class, such as New York and Chicago, have been somewhat slow in making use of the new material, doubtless because of a suspicion that it might not withstand the impact of heavy loads and constant travel.

A severe test in Chicago.

Yet in the latter city the Chicago, Burlington and Quincy Railway Co. experimented with stone, asphalt and cedar blocks at its freight yards, and after discarding all for various reasons, put down brick, with the result that after a tonage of 12,500 tons had passed over it daily for four years not a broken brick could be found. That company is so well satisfied with its experience in Chicago that it now uses it for paving all its yards where there is heavy traffic, its recent order for the St. Louis yards being a million and a half of brick.

Forecasting brick pavement works for 1894 in the U. S.

In the May (1894) number of Paving and Municipal Engineering, an excellent journal published at Indianapolis and devoted to subjects indicated by its name, a forecast is made of the extent and cost of public improvements to be made this year in fifty-four cities of the United States, based on returns received by the editor. Thirty-two cities report projected pavements as follows: Asphalt 288,163 sq. yds., brick 524,143 sq. yds, and macadam 383,086 sq. yds. The figures representing the cost are incomplete, but it is significant that the area proposed to be laid with brick is much larger than that to be covered with either asphalt or macadam, and is nearly equal to that of both combined. Louisville, Ky., appears in the list for 150,000 sq. yds. of brick at a cost of $525,000, but the bulk of the outlay for brick streets is undertaken by cities of moderate size. Thus Burlington, Iowa, is down for 40,000 sq. yds., costing $75,000; Decatur, Ill., for 33,000 sq. yds., costing $50,000; Danville, Ill., 40,000 sq. yds., costing $75,000; Huntington, W. Va., 20,000 sq. yds., costing $25,000; and Tiffin, Ohio, 25,000 sq. yds., costing $68,000. On the other hand, Chicago proposes to lay 39,000 sq. yds. of asphalt at a cost of $117,000, and 250,000 sq. yds. of macadam at a cost of $225,000, while it is investing in only 6,000 sq. yds. of brick, costing $12,000. Milwaukee is covering 100,000 sq. yds., and Indianapolis 95,066 sq. yds., with asphalt, while the latter city proposes besides to lay 40,700 sq. yds. of brick. It is evident therefore that while some cities of the first class are slow to commit themselves to brick pavements, brick is fast becoming, if it has not already become, the favorite material for towns and cities of less than the largest size.

Brick paving in Ontario.

Chatham.

So far as is known, only two places in Ontario have made use of brick as a paving material. One of these is the town of Chatham, where in 1890 a brick pavement was laid down on King street, from the Rankin House almost to the Garner House, the busiest part of the main thoroughfare. The bricks were purchased from local brickmakers and were made from clay adjoining the town. They were not burnt hard enough for durability, but the pavement is in fairly good shape yet, and all are agreed that brick is the material for Chatham, provided suitable clay could be got and the brickmakers there had the proper appliances for burning it. The other place where vitrified bricks have been put down is Toronto, and to those

Toronto.

who have not watched local affairs closely it may be news that there are four miles of streets in this city paved with vitrified brick, all of which were laid down last year. The following are the streets: Dundas street from the bend to Lansdowne avenue; Lansdowne avenue from Dundas to College; College from Lansdowne avenue to Bathurst; Bathurst from Queen to Bloor. The pavement is between the street-car rails only. The bricks of which it is composed are all imported from the United States, partly from Massillon, Ohio, and partly from Canton, Ohio. The foundation is a bed of concrete, on which is laid a cushion of sand one inch in thickness, and on this the bricks are placed on edge at right angles to the kerb. They are laid as close to one another as possible, and the interstices are completely filled with paving pitch or Portland cement. Pitch is used on Bathurst street between College and Queen, and on College street between Bathurst and Dufferin, and cement on the remainder of the pavement. The cost of paving brick laid down in Toronto is from $20 to $23 per thousand, made up as follows: Price at place of manufacture per thousand, $9 to $10.50, freight $9 and duty $3. It takes from 60 to 64 bricks to lay a square yard of pavement, allowing for breakages. The brick pavements in Toronto having been down scarcely a year do not afford data for a conclusion as to their durability; we expect them to be yet practically uninjured and as good as when laid down. This on examination we find to be the case, and although, owing to the pavement being between the car rails only and thus by its position as well as by its smoothness offering a double inducement to vehicles of all kinds, it has received more than its fair share of travel, the only visible mark of wear is a slight rounding-off of the edges of the bricks. The comparative cost of the various kinds of pavement used in Toronto is as follows, including foundations:

Cedar block on 6 in. sand	$ .75	per sq. yard.
Cedar block, on 2 layers of 1-in. boards, with tar compostion.	1.30	"
Cedar block, on 6-in concrete	1.50	"
Light asphalt, 4-in. concrete, 2-in. asphalt	2.10	"
Vitrified brick, on 4-in. concrete	2.25	"
Heavy asphalt, 6-in. concrete, 2½-in. asphalt	2.60	"
Granite sets on 6-in. concrete	3.85	"
Scoria blocks on 6-in. concrete	4.00	"

Comparison with cedar blocks as to cost.

The city authorities are very favorable to the use of brick as a paving material, considering it suitable for traffic of any kind, whether heavy or light. If good paving bricks were made here and sold for the same price as that charged by the United States manufacturers in their own markets, a saving of from 65 to 75 cents per square yard over present cost could be effected, which would reduce the cost of brick pavement to practically that of cedar blocks. In such a state of affairs there would be no choice whatever between the two kinds of pavement. The inodorous, bumpy, short-lived block would disappear forever before the clean, smooth, warm-colored and durable brick. There are miles of cedar block pavements in Toronto which are approaching the point when they must either be renewed or replaced by some better material. It would be a calamity if cedar blocks were again laid to furnish a repetition of the nuisance which this kind of pavement becomes in its unlovely old age; while on the other hand, a public benefit of no mean kind would be conferred by replacing them with smooth, lasting and sanitary brick roadways.

Cost of brick pavements in the U. S.

The cost of brick pavements in the United States varies considerably with the kind of foundation employed. It ranges from $1 to $2 per square yard, the average being perhaps about $1.50. The cost of the bricks themselves for a single course pavement at a selling price of $10 per thousand is about 65 cents per square yard. A few samples of the cost of brick pavements, together with the various kinds of foundation and methods of laying the brick adopted, may be quoted from Mr. Chase's manual, above referred to:

Bloomington, Illinois.

In Bloomington, Ill., where some of the pavements are twenty years old and but little worn, the manner of laying is as follows: The foundation is brought to proper shape and well rolled; then a course of cinders is spread on and compacted by rolling; on this is placed two inches of sand; then the first course of bricks on their flat sides with their long axes parallel to the street. Next comes an inch of screened sand, and then a layer of bricks edgewise on their two-inch surface, and long axes at right angles to the street. The bricks are then covered with sand, which is swept into the cracks, and the whole pavement rolled with a heavy roller. There is no necessity of the sub-course of brick being as hard as the upper course, but care must be taken to break joints in both courses. The entire pavement, including all materials, cost $2 per square yard. A line of pavement running to the depot had, in 1891 been down for seven years, carrying all the freight to the railway and all coal from the coal shafts, a very heavy traffic, without showing any appreciable sign of wear.

Decatur, Ill.

In Decatur, Ill., the specifications required; (1) foundation brought to desired crown 12 inches below grade and rolled with a heavy roller; (2) a course of clean gravel, none larger than a robin's egg; (3) one course of brick flatwise, then one and a-half inches sand, and a course edgewise, and brick brought to a surface by striking with a maul on a plank; (4) sweep in dry sand; (5) brick extra hard and vitrified. The cost is $1.50 per square yard. The oldest brick pavement at this place had been down six years in 1891, and then showed but little wear.

Steubenville, Ohio.

At Steubenville, Ohio, hard burned bricks are used, chiefly obtained from New Cumberland, W. Va., and have given satisfactory results. They are laid on foundations of gravel similar to that used at Decatur. The wear is estimated at one-fourth to one-half an inch in five years. Cost of pavement, $1 per square yard.

Peoria, Ill.

At Peoria, Ill., Franklin street, which in 1891 had been paved with brick three years and a half, is one of the principal thoroughfares and has a very heavy traffic. It was as pleasant to ride on as asphalt, and showed little or no signs of wear. The bricks used were larger than ordinary, being four inches thick, twelve inches long and five inches deep. They were laid on five inches of rolled gravel, the joints being filled with sand. Contract price, $1.70 per square yard.

A record of forty-two cities.

In an admirable article on the Manufacture and Use of Paving Brick, read before the International Engineering Congress of the World's Columbian Exposition by Daniel W. Mead, that gentleman gives a table of forty-two cities in the United States where brick pavements are in use, showing the number of years the pavement has been down, the kind of foundation, the per square yard and other particulars. Cincinnati is shown a quantity of pavement four years ago on six inches of con- t of $2.50 per square yard; a similar pavement in Indianapolis r square yard; one in Wheeling, W.Va., laid eleven years ago es of gravel, cost $1.35 per square yard, while the premier pave- leston, W.Va., placed in position twenty-three years ago on a f three and a half inches of sand and tarred boards, cost only uare yard. In the cities of Illinois and Iowa, where paving e largely used than in any other part of the United States, ps Ohio, a variety of foundations is employed, comprising , cinders, sand, gravel, concrete, and usually a course of brick which may be of inferior quality to those forming the actual street. A common foundation is six inches of broken stone, two inches of sand, either with or without the overlying sub- ck laid flat. Six inches of concrete is also frequently used, and nd alone forms the bed on which the bricks are placed. t-mentioned case the expense is low, as at Council Bluffs, where t is stated to have cost only $1.32 per square yard. A pave- on six inches of broken stone with a course of brick flat cost at 2.16 per square yard; at Springfield, Ill., one on six inches of $1.50 per square yard; at Clinton, Ia., one on six inches of with sand, $1.35 per square yard; and at Dubuque, Ia., six crete foundation brought the total cost of pavement up to $1.69 rd.

Foundation for a Brick Road-Bed.

Importance of a good foundation.

oundation is as essential with vitrified brick as with any other ng material. However excellent the surface covering of the e, it cannot but fail of achieving the best results if it does not per substructure. The road-bed should be thoroughly drained, e the greatest possible freedom from moisture, that arch-enemy , equally objectionable in fluid or frozen form. When brought grade, the whole surface of the roadway should be thoroughly by rolling or ramming. If the bed to overlie this is of gravel or it should consist of pieces of uniform size, not too large, and . If of concrete, the sand entering into the latter should be ment of first-class quality, and there should be a due proportion mixture, say three parts of sand to one of cement; and the stone to complete the concrete should be angular, with rough d not excessive in size. The concrete when deposited on the uld be rammed until loose mortar appears on the surface, and should be allowed for it to set before placing the brick in posi- e concrete a layer of sharp, dry sand should be spread to the n inch or an inch and a half, to act as a cushion on which the est. The bricks are placed on this on edge at right angles to d in order that the joints may be broken, each alternate row t the kerb with half a brick. The bricks should be as close to

es)

one another as it is possible to lay them, and the interstices filled in with sand, paving pitch or cement. The last named is preferable for a lasting and substantial piece of work, as it is impervious to water and not loosened by the heat of the sun, which is not the case with sand and paving pitch, respectively. A drawback to the use of cement for this purpose is the length of time it takes to harden, while the pitch consolidates in a few minutes. It is difficult to exclude traffic from a street long enough to allow the cement to thoroughly and properly set.

Facility of making repairs or improvements with brick pavement.

It is frequently necessary to disturb the surface of the street in order to make repairs to sewer and gas pipes, water mains, etc., and the facility with which a pavement can be taken up and relaid is an important consideration. Brick is far ahead of asphalt in this particular, and is as easily taken up and relaid as either granite or wooden blocks. When the joints between the bricks are filled with sand, the bricks may be removed, cleaned and placed in position again with little or no trouble, but if pitch or cement be used, such repairs generally involve the destruction or rendering worthless of the bricks removed.

Suiting a foundation to the necessities of a street.

It is evident that for heavy and constant traffic, a foundation such as is described above is an absolute necessity, if a brick pavement is to have a fair opportunity of proving its smoothness and durability. For lighter traffic a less expensive foundation may suffice. The engineer of an Ohio town states that last year he put down a considerable area of brick pavement on a foundation of six inches of clean gravel, and one inch of sand. The usual drain pipes were omitted. The whole pavement, when completed, cost $1.28 per square yard. Such construction might perhaps serve the purpose in small towns, but could scarcely be expected to stand the strain of heavy traffic. Mr. Mead says:

"For light traffic, the fragmentary materials, (rubble, gravel, sand, etc.,) or sand with a layer of brick laid on their side, or six inches of concrete, make good foundations, the selection depending on the local resources. For medium traffic, nine inches of stone or gravel, or six inches of gravel or stone with a layer of brick laid on their sides, bedded in sand, or six inches of concrete, will give good results. For heavy traffic, the stone or gravel should be at least one foot in thickness, or the concrete at least nine inches."

Preferred size f brick.

Bricks of the standard size (which in Canada is 2¼ x 8¼ x 4¼ inches) are to be preferred. They are more likely to be thoroughly vitrified than larger blocks, which are frequently found unvitrified in the centre, and they possess an additional advantage from the manufacturer's point of view. In almost every kiln of brick burnt there is a percentage of the output too soft for paving purposes. These, if of the ordinary size, may be used in building, or for sewer arches, while if too large or of an odd size they would be hardly saleable.

BEST CLAYS FOR PAVING BRICK.

Tests of a good quality of clay for vitrifying.

All clay will not make good paving brick. Clay that will yield excellent building brick may be altogether lacking in the qualities necessary for good paving material. A brick that is made from coarse clay or one that has an excessive percentage of sand will be open and porous or easily broken, and

The test of analysis.

The test of trial.

ıg purposes. The best bricks are those made from a tough, plastic,
with a fine grain, that will burn hard without warping, twisting
sily under a strong heat. It is impossible to determine either
sical properties or the chemical analysis of a clay whether it will
isfactory paving brick. The latter method of examination may
to give a negative result; that is, if it reveals a large preponder-
sirable, or an insufficient proportion of necessary elements, we
that the clay in question is unsuitable for the purpose. But a
y which passes muster under chemical analysis may fail when
actual test. "The analysis of a clay is only presumptive
:s adaptation to the various departments of clay working, and
aken as conclusive. The intense heat of the kiln may effect
ıs and develop combinations which are beyond the reach of
ents. The presence of a great mass of highly heated material
erts an influence that cannot be produced in the laboratory."[4]
vard Orton, jr., E.M., in a well written series of papers on the
Industries of Ohio, which have appeared in The Clay Worker
), agrees that the only conclusive test of the quality of a clay is
He says: "The heat test of clays, whether applied in special
ilns in a laboratory or carried on in the ordinary course of
in the kilns of a clay plant, is the only important and convincing
can apply. By it each man learns what he needs to know, and
the ultimate facts be known, for no matter what the source of
r expectations may be, there is no assurance of the quality of
ctual trial. Even the predictions of a chemical analysis are
seful, for while they are founded on the results of well known
e still too many unknown and unexplained contingencies in the
f clays to make a chemical prediction more than a reasonable
By an analysis certain things are indicated; we expect a fire
elop a result in accordance; it probably will, wholly or in part;
lly only in part, for such is the infinite variety of composition
ion in clays, that their products are somewhat like the human
alike."[5]

Constituents of clay.

e immediate or ultimate product of the decomposition of felspar,
he felspathic ingredients of granitic rocks. The essential
s a hydrous silicate of alumina, known as kaolin, composed

. Brown, formerly chemist of the United States Department of Agriculture,
Manual, p. 167.

-Worker, April 1894, pp. 147-8. Mr. Orton's work in the line of clay-
amics has recently been recognized. By enactment of the General Assembly
se of Practical and Scientific Instruction in the Art of Clayworking and
lded to the educational work of the University of that State. The department
organized with Mr. Orton as director, and the first term opens on September
e course is intended to afford to young men engaged in brick works and
portunity to gain as much knowledge of the principal scientific studies
raft, with as little expenditure of time on other branches of science not so
o their work, as is possible. The course extends over two years, and the
ers physics, physical geography, chemistry, algebra, geometry, shopwork,
eneral and economic geology, mechanical drawing and drill. Particular
given to chemistry, including the analysis of clays, limes, cements, felspars,
glazes, slips, enamels, etc. Tuition is practically free. This is the first
history of this continent in which steps have been taken to put the ceramic
e plane occupied by those of mining, metallurgy and agriculture.

of silica 46 3 per cent., alumina 39.8 per cent., and water 13.9 per cent. This may be considered pure clay, which is rarely met with in nature. The clays of common occurrence contain a larger proportion of silica and a smaller proportion of alumina than kaolin, and variable quantities of numerous other ingredients, the chief of which are lime, magnesia, potash, soda and iron. The alkaline constituents of clay may be either the elements contained in the felspar of the original rock, or derived from extraneous sources; the iron is probably in most cases an added element, though originally present in some felspars as a coloring matter. Clays, considered with reference to the manner of their occurrence, may be either residual or sedimentary. Residual clays are the product of the disintegration of rocks in place, and where such a process has gone on free from the intrusion of other impurities, the leaching out of the alkalies may have left a bed of pure or nearly pure kaolin. Sedimentary clays are those which have resulted from the grinding up of rocks by glacial action, or the working over and transportation of residual beds. This class of clays is more likely to have retained the original composition of the rocks from which they were derived. Clays are found in all geological formations except the very oldest, and in many cases have, through the influence of heat and pressure, become indurated into compact rocks or shales. No one geological series has a monopoly of clay suitable for the manufacture of paving brick. The shales of various ages are now extensively used for the purpose, and even some drift clays, subjected though they have been to so many vicissitudes and exposed to contamination from so many sources, have been found to possess the requisite qualities.

Residual and sedimentary.

Shales.

An examination of the analysis of samples of clay used in making paving brick in various and widely separated portions of the United States shows that a considerable range is permissible in the proportions in which the main ingredients are present. It does not appear to be essential that the silica and alumina should bear any fixed relation to each other in quantity. In some samples the former is high, and the latter low, while in others the reverse is the case, with apparently little or no effect upon the quality of the product.. Alumina shrinks, warps and cracks greatly in drying, but gives plasticity and adhesiveness to the clay and strength to the product. Silica prevents cracking and distorting, the more silica being present the less the shrinkage. But the greater the proportion of silica the less the plasticity and adhesiveness of the clay, and the weaker and more brittle the product. Neither does there appear to be any fixed standard for the fluxing constituents, either singly or taken together. What is doubtless true is that these should not fall below a minimum, otherwise the clay would refuse to vitrify; nor exceed a maximum, otherwise it would fuse too soon and melt out of shape at too low a heat.

A wide range of proportions permissible.

On the subject of the physical and chemical qualities of vitrifying clay, Mr. Orton writes as follows in the series of articles above referred to:

"In examining the subject it is found that clays used for making vitrified brick are chemically different from those used in making any other form of vitrified wares. Hence the following statements may be applied to all clays in which vitrification is an essential quality.

What vitrification means.

e taking up the consideration of the clays, it is proper to define nore fully what is meant by the term vitrified.

e third paper of this series, the term was defined as indicating the usion and fritting of the particles of the clay ware into a new mpound, not necessarily glassy, but indicating by its fracture that ical union has begun to take place.

egree to which such vitrification has taken place in a burnt clay by its ability to absorb water, for as the chemical union pro- pores of the clay become more and more constricted and the appe- ter less and less. If the clay be a good vitrifying variety, it will ease to absorb water at a temperature some distance beneath its at. Other clays, burnt at something near the same temperature, nto combination to a certain extent, but still absorb water freely. are perhaps somewhat vitrified after being burnt under such con- t under the classification proposed they must not be included as lays.

hysical peculiarities which mark vitrification in a burnt clay are lal fracture, absence of pores, and blending of the ingredients into Cracks, fissures and cavities may be found, but porosity must not well vitrified clay, and the original particles must have begun to ne bond of heat instead of the bond of plasticity.

npossible to convey adequately by words the peculiarities of frac- indicate vitrification, but it is a quality which the natural sense rver readily teaches him to detect.

Qualities of a vitrifying clay.

cation is thus seen to be a physical state or condition which any sume if it is heated to the requisite point. The qualities which have to be profitably made into vitrified product are as follows:

Balance of vitrifying and fusing temperature.

re must be a balance between the vitrifying temperature and the erature. Some clays begin to vitrify at low heat and become n-absorbent without ever approaching to a point where the clay t or bloated. Others stand heat well up to a certain limit and pidly. Obviously, the latter would not do for a vitrified product, be impossible to burn a kiln of it without overburning a large order to obtain a sufficient heat to cause the rest of the kiln to rify. There must be a margin, or a tolerably broad range of s, inside of which the vitrifying action takes place without fusion; for if a burner is working between two extremes, too tion and porosity of his output on one side, and melted and e on the other, it is plain that he could not pay Peter without rom Paul.

ay have this first great condition, it can be profitably worked, e will depend partly on two other factors, 2nd, plasticity; 3rd,

Plasticity.

e importance of the requisite plasticity is easily seen, for if it is d it must be obtained by mixture which may interfere with the re important quality of vitrification. Again a balance of quali- ed. Too great plasticity causes imperfect arrangement of the particles of the clay in passing through the die of the machinery. Too little causes surface imperfection, cracks, toughness, etc. The majority of the vitrifying clays are not naturally very plastic as they occur; they may have been once, but the quality is gone, and it is only by fine crushing and very thorough tempering that plasticity sufficient can be induced. However, the faults of plasticity can largely be conquered by the use of proper mechanical means, while the vitrification depends on inherent chemical properties which we cannot vary or alter.

Color.

"3. The color of the ware is only important in view of a singular prejudice which the public have cultivated against light colored materials. The popular idea is that vitrification is measured by the dark color of the product, and that light colors are prima facie evidence of softness. This is by no means true. Many of the impure fireclay beds of the State make most excellent vitrified brick, but cannot be sold on account of their naturally light color. This difference is due more to the condition of the iron present than to its amount. In the light colored clays the iron is largely present as grains, while in most shales it is in the state which affects equally every particle of the clay, whether chemically combined or not."[6]

Sources of vitrifying clay.

Mr. Orton goes on to enumerate the sources from which vitrifying clay is obtained in Ohio. He states these as three: (1) The shale clays, coming largely from the coal measures, but represented in all of the older deposits as well; (2) the impure and low grade fire clays, coming from the coal measures; (3) river clays or sedimentary deposits of recent origin. The fire clays, together with the coal measures to which they belong, are absent in Ontario, although it is claimed that some beds of the Hudson River shales possess the qualities of fire clay. As to the sedimentary deposits of Ohio, they have so far found but limited use in producing vitrified wares, being too fusible, too plastic, and containing an undue proportion of limestone gravel, which spoils the surface of the ware after burning. Their counterparts in this Province supply the raw material for numerous building brick industries, but as yet no attempt whatever has been made to test their suitability for the manufacture of paving brick. Such efforts have been confined exclusively to the shales of our Hudson River and Medina formations, and it is encouraging to those engaged in these efforts to know that in Ohio the use of shale in the production of paving brick has given satisfactory results and is rapidly extending. It is stated by Mr. Orton that none of the three classes of clay enumerated above is in itself a perfect material for the purpose to which it is applied, though instances are found in which each is used alone with satisfactory results. The shales and river clays are too fusible and lose their shape at too low a heat, but vitrify perfectly. The fire clays are more refractory, owing to their high percentage of silica and comparative freedom from fluxing impurities, and they keep their shape well, but at the expense of vitrification. On this account a mixture of fire clay with either shale or river clay improves the quality of the product. As regards plasticity, the shales are as a class not sufficiently plastic to work alone; the river clays are too plastic, while the fire clays leave little to be desired in this respect. As to color, the shales

Advantages of a mixture of clays.

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[6] The Clay-Worker, May, 1894, pp. 544-5.

Analyses of Ohio shales.

and river clays burn dark, the fire clays light. Both in point of plasticity and color, therefore, an admixture of fire clay with shale or river clay is found to be mutually advantageous. Mr. Orton gives an analysis of shale clays used in the manufacture of paving brick and sewer pipe at a number of establishments in Ohio, which is as follows :

Elements.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Silica (total)	57.15	58 30	57.10	49.30	57.45	55.60	58.20	58.38	57.28	57.40	56.61
Alumina	20.26	19.67	21.29	24.00	21.06	24 34	22.47	20.89	21.13	21.20	21.63
Water (combined)	5.50	5.15	6.00	9.40	5.90	6.75	6.15	7.53	5.22	7.75	......
Clay and sandy impurities (total)	82.91	83.12	84.39	82 70	84.41	86.69	86.82	86.80	83.86	86.35	......
Oxide of iron	7.54	7.43	7.31	8.40	7.54	6.11	5 63	5.78	8.52	6.57	7.08
Lime	.99	.84	.29	.56	.29	.43	.62	.44	5.79	1.00	1.11
Magnesia	1.62	1.35	1.53	1.60	1.22	.77	.98	1.57	2.13	1.40	1.41
Potash	3 05	3.04	3.44	3.91	3.27	3.00	3.08	4.68	......	4.10	3.51
Soda	.58	.73	.61	.19	.39	.09	.42	.34	.....	1.00	.48
Fluxing impurities (total)	13.69	13.39	13.18	14.63	12.71	10.40	10.73	12.81	16.44	14.07	......
Moisture	2 70	2.65	1.30	1.20	1.90	2.65	1.65	.....	......	......	......
Total	99 30	99.16	98.87	98 54	99.02	99 74	99.20	99.61	100.07	100.42	......

1. Bucyrus Brick and Terra Cotta Co., Gloucester, shale.
2. Bucyrus Brick and Terra Cotta Co., shale and plastic clay mixed.
3. Royal Brick Co., Canton, O., Canton shale.
4. Waynesburg Brick and Clay Mfg. Co , Waynesburg, shales.
5. Ohio Paving Co., Columbus, O., Darlington shales.
6. A. O. Jones Co., Zanesville, O., shale and fire clay mixture.
7. T. B. Townsend & Co., Zanesville, O., shale and fire clay mixture.
8. Columbus Sewer Pipe Co., Columbus, O., Huron shales.
9. Akron Vitrified Press Brick Co , Independence, Bedford shales.
10. Akron Vitrified Press Brick Co., Independence, another sample.
11. Average of preceding ten analyses.[7]

The average composition shows a clay containing 84.78 per cent. of clay base and silicious matter, and 13 22 per cent of fluxes.

HUDSON RIVER AND MEDINA SHALES.

Comparison with the shale of Ontario.

A comparison of the chemical composition of the Hudson River and Medina shales of Ontario as given elsewhere in this article with that of the Ohio shales in the above table shows that the former contain a larger proportion of silica and a smaller proportion of alumina than the latter. The percentage of iron in both cases is nearly the same, while there is more lime and magnesia in the Ontario shales than in those of Ohio. As to the alkalies, potash and soda, the analyses of Ontario shales showing these constituents are too few in number to admit of a comparison being made. Judging from the chemical constitution only, the conclusion might be reached that on the whole the shales of Ontario, as represented by the samples of which analyses is given, are likely to prove less refractory than those of Ohio. The surplus of silica is counterbalanced by the deficiency in alumina, while the larger bulk of fluxing impurities would indicate the likelihood of greater fusibility. Whether this is an advantage or the reverse depends entirely upon the degree of ease with which fusion takes place in any given sample of clay. If there is sufficient refractoriness to permit of thorough vitrification before the point is reached when the ware breaks down and loses shape, the easy fusibility is a desirable quality, as less heat, and therefore less fuel, are required to complete the vitrifying process. If on the other hand fusion occurs and the product is run or twisted out of shape at a comparatively low temperature, it will be impossible to produce a properly vitrified article. Experiments so far point strongly to the conclusion that the Hudson River and Medina shales of Ontario are not too easily melted, but are sufficiently refractory to admit of proper vitrification, and this without requiring an excessive degree of heat. The samples of paving brick made from them, well vitrified and yet true in shape, testify that such is the case. These will be dealt with later on.

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[7] The Clay-Worker, May, 1894, p. 546.

Analyses of U. S. paving clays.

In The Mineral Industry (1893) a table of analyses is given of paving brick clays from a number of localities in the United States, which is said to be very complete, and compiled from official sources. The table is interesting for purposes of comparison with the one just quoted. It will be noted that the average silica contents of the clays cited therein is considerably higher than that of the shales whose analyses are given by Mr. Orton.

Locality.	$Si\,O_2$.	$Al_2\,O_3$.	$Fe_2\,O_3$.	$Ca\,O$.	$Mg\,O$.	$Ti\,O_2$.	Alk.	$H_2\,O$.
Bloomington, Ill	67.80	11.55	6.50	8.90	5.32	.....	2.42	0.20
Burlington, Ia	77.40	11.74	12.31	1.60	1.91	.....	4.23	....
Clinton, Ia	73.82	15.88	9.16	trace	trace	.....	4.50	3.50
Franklin County, Kan	59.60	17.86	14.94	0.79	0.81	.....	..	6.00
Leavenworth, Kan	58.45	21.96	8.43	1.05	1.47	.....	4.00	6.51
Flint Ridge, Kan	58.20	29.80	5.40	6.00	.....	.....	.....	0.60
Cheltenham, Mo	61.22	25.64	3.47	.....	.....	.....	1.31	9.68
Montgomery, Mo	43.93	40.09	1.70	.....	.....	.....	0.20	14.60
Kansas City, Mo	64.37	19.73	9.07	0.82	2.32	.....	3.78	....
Cumberland, W. Va	69.02	22.07	4.53	1.70	0.38	.....	2.68	.....
Nuzum's Mills, W. Va	59.25	32.26	1.67	7.16	.....	.....	.....	6.30
Mount Savage, Md	39.90	30.08	0.88	.....	.....	.....	2.30	13.90
Robbins, Tenn	70.57	15.19	7.97	0.78	0.32	.....	2.30	....
Hornellsville, N. Y	67.29	15.85	6.16	0.95	0.19	.....	8.71	....
Warners, N. Y	52.30	18.85	6.55	3.36	4.49	.....	6.00	8.34
Woodbridge, N. J	42.23	39.53	0.50	0.01	.....	1.40	0.49	16.80
Phillipsburg, N.J	56.78	17.38	0.50	4.14	3.15	.....	3.42	7.60
Columbus, Ohio	57.45	21.06	7.54	0.29	1.22	.....	3.66	7.80
Canton, Ohio	53.38	19.36	14.86	1.48	1.06	.....	.....	.....
East Palestine, Ohio	57.80	25.54	2.51	0.25	0.61	.....	2.69	10.60
Haydensville, Ohio	76.24	16.87	0.16	.....	0.50	.....	1.09	4.90
Woodlawn, Penn	42.15	31.43	2.32	0.32	2.01	1.00	.....	10.60
New Brighton, Penn	67.36	22.05	5.61	0.86	0.36	.....	5.40	.....
San Francisco, Cal	56.51	21.33	0.29	.....	3.53	.....	trace	6.30
Golden, Col	52.41	32.21	0.66	0.20	0.60	.....	0.61	14.05
Winchester, Ill	23.15	17.08	.....	.....	0.28	1.20	1.10	.....

These analyses exhibit surprising variations in the composition of materials used for a common purpose, not only so far as the silica and alumina are con-lso in a smaller degree as regards the fluxing impurities. They e as disclosing the fact that clays of the most unlike constitution in the manufacture of paving brick.

TS OF FLUXING INGREDIENTS ON VITRIFICATION.

s the part played by the minor or fluxing ingredients of the clay of vitrification, Mr. Mead says:

The fluxing ingredients of clays.

nd magnesia, while infusible in themselves or with alumina, fuse ce of an excess of silica, as do also several other common ingre- and form a 'vitrified brick.' It is found that potash has the most effect on clay, after which follow soda, lime, magnesia and iron, named. To 'vitrify,' a clay should contain at least three per or three and one-half per cent. soda, or five per cent. of lime or eight per cent. iron, or a combined proportion of any or all of equal to these amounts. An appreciably less amount of these ents will leave the product more of the nature of a fire-brick, d porous, and, as a rule, unfit for paving purposes. A greater an above specified is desirable and will make the clay more easily less heat, and is to some extent a measure of its economic manu- lower heat and consequently less fuel will be required in its burn- eat an amount of these fluxes, amounting perhaps to three times s above mentioned, will render the clay hard to handle on account ility. According to Richter, lime and magnesia are more active s than potash and soda, but his conclusions do not agree with perience. The presence of lime or magnesia in a paving brick in antities is not believed by the writer to be detrimental to the ists in a finely divided state and is intimately commingled with stituents, so that a silicate of lime or magnesia will be formed in The Milwaukee building brick is one of the best of common contains a large percentage of lime, and Portland cement con- s high as sixty per cent. of lime. In each case however the lime e chemical union with the other elements of the material. Iron le quantities has a fluxing effect with silica, and to this extent gether and gives it strength. It is not the most valuable of con- his regard however, and its presence is not essential to a first- brick. Iron, when present, is usually in the form of hydrous protoxide of a yellowish or bluish color. During the burning, the tallization is expelled and the iron takes the form of the red per- its color to the material in proportion to the amount present. oda fuse at a lower temperature than the other constituents of ir presence in suitable quantities is desirable for the manufac- fied paving brick."

Mead's testimony.

e remarks on the same subject:

Chase's testimony.

very injurious to the paving brick, as it is changed to caustic lime nd a small amount of moisture reaching this will cause it to slack rate the brick. A small amount of magnesia aids in producing Iron is not injurious in a paving brick; but in a brick to resist high temperature six per cent. of iron makes it useless. Alumina, and not iron, gives elasticity to the brick, is tough and binding, readily fusing in the presence of silica. The other constituents are impurities and act as a flux."[1]

PHYSICAL PROPERTIES OF CLAY.

The shales.

The physical properties of clay have an important bearing upon its fitness for use in the manufacture of paving brick. The hard, compact shales of the older formations, subjected as they have been in past ages to great heat and pressure, have to some extent lost that plasticity which is necessary to the proper handling and working of the raw material; hence such shales have to be reduced by mechanical means to a finely divided condition, and carefully tempered by the addition of water before they are in a condition to undergo the processes of manufacture. The fineness of the particles of which clay is composed likewise has considerable influence upon its behavior in the kiln. Coarse clays are difficult to vitrify even when the fluxing constituents are present in sufficient proportion, on account of their ability to withstand a large degree of heat. The more finely divided the clay, the more readily is it vitrified, and the tougher, stronger and more impervious to moisture is the product. The several ingredients of the clay may also vary in their action according to the condition in which they exist. On this point Mr. Mead says: "The uncombined silica may be more or less finely divided, and its condition has its effect on the action of the fluxes. In clays derived from felspathic or micaceous rocks, undecomposed felspars and micas sometimes occur. Lime, instead of being finely divided, may occur as lumps or pebbles, in which condition it will unite with the other ingredients only on the surface, the balance burning into caustic lime, which on exposure will gather moisture and slack, disintegrating and crumbling the brick." It is even conceivable that two samples of clay, substantially identical in chemical composition so far as the proportions of the several constituents are concerned, may act quite differently in the kiln, owing to the different condition in which these constituents are present in the respective samples. A clay full of fragments of the original rock, for example, would be likely to require a considerably higher temperature for its vitrification than a clay resulting from the more complete degradation of the same rock; and this difference in temperature might bring about the production of two very unlike samples of brick.

Fine division of constituents a pre-requisite.

The character of plasticity.

One physical property, it may be remarked, is possessed by clays alone among the mineral substances found in nature, viz., plasticity. The cause of the plasticity of clays, by virtue of which they may be moulded into almost any desired form, does not seem to have yet been thoroughly explained, but it evidently depends largely upon the presence of the chemically combined water, as when this is driven off by heat the clay loses its plasticity, which can never be restored. Dr. Koenig of the University of Pennsylvania, who has made a study of this subject by means of microscopic investigations, states that kaolin or pure clay is composed of minute particles, loosely aggregated and invisible to the naked eye. Magnified 1,100 diameters, these particles look like globules, and are not very unlike fish roe in In Dr. Koenig's opinion these particles are not crystalline; and upon their similarity to globules of starch, as they are capable water and of enlarging and passing into a plastic paste, the lity of which is accounted for by his assumption of the rounded ltimate particles. Pure alumina is not plastic; neither is pure hen in chemical combination as a silicate of alumina there is is highly interesting property. If there be more silica present aken up in chemical union by the alumina, the result is a lessencity, which goes on decreasing in proportion to the quantity of Clay loses its plasticity entirely at a low red heat, probably ° F.[9]

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[1] Brick Pavement, pp. 14-15.

Manufacture of Paving Brick.

The stiff mud and dry press methods.

ary methods of making common brick require some modification acture of paving brick. If the raw material is shale, it is first powder in a granulator or dry pan, and then thoroughly tempered before passing to the brick machine. The auger type of brick e one more commonly employed, and the clay is handled in the own as "stiff mud." The "soft mud" process is not considered the manufacture of paving brick. Attempts are being made to ry press" method, and on certain kinds of clay with a considerf success. The drying of the brick previous to their burning is part of the process, and is best done on hot or slatted floors, r tunnels, by means of artificial heat. Outdoor drying cannot on where the industry is conducted on a large scale. In the g of the brick, the best results are obtained by means of the " kiln. The fires are started slowly, in order to allow the water held in the clay to pass off as steam, which it does completely ature of 212° F. This process is technically called "water-When the smoke issuing from the kiln shows no further signs of m, the heat is gradually increased, and at a little above 1,000° F., heat hardly perceptible in daylight, the combined water also

Burning.

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ndix to Brick and Tile Making (London, Eng., 1868), Mr. Charles Tomlinson, es thus as to the cause of plasticity in clays: "We have seen that clay stic when its chemically combined water has been driven off. Still however e said to be the cause of plasticity as a general property, since we have in more perfect example of plasticity even than in clay; and few substances c than sealing-wax at a certain temperature. A clear idea of plasticity and ther mechanical properties of matter may probably be gained by considering ons of the forces of cohesion and adhesion, and by bringing these in their wton's great law of attraction, which, whether exerted between atoms or tly as the mass and inversely as the squares of the distance. . . . Now arranging the particles of clay at that precise distance that shall impart of Nature's secrets that we have not yet succeeded in penetrating. It may umstances under which the clay is formed and deposited, or the time that e its formation, or the pressure of the superposed layers, may have so arranged to enable them to become plastic when the proper proportion of water is y be that a certain state of disintegration is required on the part of the e silica, so that their proximate elements shall be neither too fine nor too ay be that the silica, in combining with the alumina, separates the atoms of ecisely those distances required for the development of the property; or, ence of a small portion of animal or other organic matter in clay may have with this remarkable property."

passes off. Any organic matter present is now eliminated, and sulphur compounds broken up, part of the sulphur going off in the smoke. This is a critical stage of the operation. As the combined water is expelled the particles of the clay begin to settle together and the pores to close up; and if the heat be too quickly raised this process goes on so rapidly at the outside of the bricks that the gases evolving in the centre find it difficult or impossible to force their way out. In this case the imprisoned gases will distend or "bloat" the bricks and perhaps ruin their shape altogether. This is more apt to occur in the burning of large paving blocks, or bricks of extra size. The chemical changes are accompanied by corresponding alterations in the physical conditions of the clay. The expulsion of the water has brought about a shrinkage in the size of the bricks, which are now denser, harder, and stronger than before. Their weight is subject to no further reduction. If the contents of the kiln have safely passed through this ordeal, there is usually little further need for fear in the burning. **Vitrification.** The heat is again raised, and vitrification shortly begins to set in, whereby the various constituents of the clay are chemically combined into one compound silicate. This process may be regarded as the initial stage of fusion, but must not be carried to the actual point of fusion, otherwise the clay will melt and run entirely out of shape. As the heat becomes nearly as great as the clay can bear, the structure of the latter is so changed that instead of exhibiting a rough, stony fracture, the clay will break with sharp edges like glass, and will no longer absorb water.[10] After vitrification occurs, the kiln must be gradually cooled down previous to the removal of the brick. From two to four days are required for "water-smoking," from four to six for burning proper, and from three to five for cooling. **Cooling down.** If cooled too rapidly, the bricks become glassy and brittle, while by allowing the heat to slowly subside they are toughened, and as it were annealed. Indeed the term "annealed brick" has been proposed as a substitute for "vitrified brick," as being more descriptive of the essential quality of a first-class article. The word "vitrified" conveys the idea of a glassy, and consequently a brittle product, while the fact is that good paving bricks, though "vitrified" in the sense of being rendered impervious to moisture, or nearly so, are tough and very difficult to break. As a matter of fact, it is possible to produce a paving brick of fair quality without vitrification. Where the raw material approaches a fire clay in its composition, it may be difficult or incapable of fusion, and yet may yield a paving brick suitable for a warm climate and for moderately heavy traffic. Bricks made in certain parts of West Virginia from clays of this kind have given good satisfaction. A degree of vitrification is however requisite for a rigorous climate like our own, as a brick which would absorb any appreciable quantity of moisture would soon be shattered by the keen frosts of our winters.

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[10] The degree of heat required to bring about these changes Mr. Orton found to vary between 1,800° F. for shales and 1,920° F. for fire-clay, the product being paving bricks. The temperature of open hearth steel in the furnace before being tapped for pouring was 2,660° F.: of mill iron as it ran from furnace to casting bed 2,225° F.; inside of boiler firebox 2,175° F.: of another firebox 2,295° F. The Clay-Worker, April, 1894, p. 447.

QUALITIES OF PAVING BRICK.

Hardness, specific gravity and crushing strain.

A first class paving brick will resist a file or emery wheel almost as effectually as a piece of cast iron. It should have a specific gravity of about 2.25, and be capable of sustaining a crushing strain of about 12,000 lb. per square inch. Bricks of fair quality will vary in specific gravity from 2.03 to 2.41, and in crushing strain from 9,000 to 13,000 lb. per square inch. The crushing strain of granite varies from 5,000 to 21,000 lb. per square inch. The test for crushing strain however is difficult to apply, and unless made under definite conditions is uncertain in result. The transverse strength of a brick, viz. the weight it is capable of sustaining in the centre while the ends are resting on supports, is more easily ascertained, and representing as it does both the compressive and tensile strength of the material, probably indicates more nearly the value of the brick for actual wear in the street. A standard brick should exhibit a transverse strength of at least 1,600 lb. to the square inch.

Absorption.

The percentage of water absorbed by a paving brick is an important test of its quality. The best bricks will not take in more than 2 per cent. of their own weight after an immersion of three days, while a common red building brick which has a specific gravity of 1 82 per cent. will absorb as much as 15.13 per cent. of its own weight in the same time. The ratio of absorption, however, is usually greater than 2 per cent., and in some cases runs as high as 3 and even 5 per cent., though brick of this latter quality should be looked upon with suspicion, and as scarcely suitable for use in northern climates. The presence of caustic lime in a brick is also revealed by the immersion test. Caustic lime has a great affinity for moisture, and if it be present it will absorb the water and break or crack the brick, or will form "poppers" on the surface.

Abrasion.

It is customary to test paving brick for its resistance to abrasion by placing the specimens in a foundry tumbler with pieces of cast iron, and after submitting them to so many hours' friction at a given number of revolutions per minute, to calculate the loss as compared with the original weight. No standard of comparison has yet been fixed for this test, but it is useful in determining the resisting powers of bricks of different makes, or of bricks delivered on a contract as compared with the samples.

THE CLAYS OF ONTARIO.

The Erie and Saugeen clays.

No general or systematic examination has yet been made of the clay or shale deposits of Ontario with a view of determining their value for manufacturing purposes. There is abundance of clay adapted for the production of building brick in almost every part of southern and western Ontario. In very many places pockets of clay on the surface of the drift are utilized for this purpose, some burning red and some white. These local deposits are usually of limited extent and of variable character, and are unlikely to prove sources of supply of paving brick. The Erie and Saugeen clays are widely distributed throughout the Province, and are generally capable of being burnt into building brick.

The Erie clay, which when moist is of a blue color with thin gray bands, burns white and is largely used for brickmaking where it does not contain too great a proportion of lime. In the northwestern portion of its area, as in the counties of Bruce and Huron, it is frequently too calcareous to admit of successful use in brickmaking. The thickness of the Erie clay is thought not to exceed 200 feet. The Saugeen clay, which overlies the Erie, and is sometimes separated from it by beds of sand, is thinly bedded and of a yellowish or brownish color, contains considerable lime, and is extensively used in the manufacture of bricks, which are usually red in color. The thickness of the Saugeen clay is probably somewhat less than that of the Erie. The classification of the stratified clays of Ontario into the Erie and Saugeen beds was first made by Sir William Logan, and while doubtless it is sufficiently accurate in the main, there are localities where deposits of clay are found which do not accommodate themselves to this division. One example is in the exposure made at the works of Messrs. Taylor Bros. on the Don, near Toronto, where overlying a deposit of brown sand which covers the till, there is a bed of dark brown clay twelve feet thick burning red. Above this, but separated from it by several other beds, and immediately below the surface, is a bed of brown clay sixty feet thick burning buff. If we have here the Erie and Saugeen clays respectively, they give precisely the opposite colors on burning to those assigned them by Logan. So far as known, no experiments have been made with the Erie and Saugeen clays in the manufacture of vitrified brick, but probably they would be found to contain too large a proportion of lime for successful use. The boulder clay or till of course cannot be availed of in the manufacture of bricks of any kind on account of the great number of pebbles and boulders which characterize it.

The Palæozoic shales.

The Palæozoic formations of Ontario, which end in an unimportant and restricted section of the Chemung and Portage group of the Devonian series, do not afford so great a variety of shales and clays as a complete section of the geologic scale would do, and are notably deficient in the fire clay deposits so characteristic of the carboniferous measures. Shales and argillaceous rocks however form part of nearly every one of the formations subsequent to the Archæan. In the Hudson River and Medina formations we have inexhaustible supplies of material from which not only building brick, pressed brick and sewer pipe may be made, but also paving brick of excellent quality. The Hudson River shales are exposed in a number of places in the neighborhood of Toronto, in particular by the Don and Humber rivers and at Mimico. At the works of Messrs. Taylor Bros. on the west bank of the Don the shale, which immediately underlies the till, rises ten feet above the level of the valley, and has a depth as ascertained by borings half a mile distant of about 400 feet. Above the shale is the boulder clay in a bed three feet thick, which is followed by a deposit of coarse sand colored brown by iron stain, about eighteen feet in thickness; this is succeeded by a bed of clay twelve feet thick, dark brown in color, which burns red, and overlying this is ten inches of light brown clay exceedingly fine in grain, which burns white. Next in ascending order is a grayish

Hudson River in the Don valley.

Taylor Bros. works.

clay six feet in thickness which burns gray, or green when exposed to intense heat, and above it is a similar thickness of reddish clay burning red. Over this and extending to within a few inches of the surface is a thick deposit, probably sixty feet in perpendicular depth, of a brown thinly-bedded clay, which burns buff. From a mixture of the several clays with one another and with the shale bricks of a variety of pleasing colors are produced. A quarry has been opened on the shale to furnish material for the manufacture of pressed brick, and is now perhaps eighty feet in depth. It shows the shale to be interbedded with thin bands of limestone which have to be culled out. This firm, with characteristic energy, have added paving brick to the other branches of their industry, already including pressed brick of a great many kinds and colors, plain and ornamental, terra cotta, and enamelled brick. An exhibit of Don Valley pressed brick took the highest award at the World's Columbian Exposition. A large kiln has been erected on the continuous principle, and it is the intention to undertake operations on a considerable scale in the manufacture of paving brick from the shale. Of course the shale requires to be ground before being worked, and as it is found that the greater the depth the harder the shale, it is customary to dig a supply and expose it to the disintegrating influences of the weather for a time. Following is an analysis of the Hudson River shale of which the Don Valley pressed bricks are made, furnished by the kindness of Dr. Coleman of the School of Practical Science :

Analysis.

Hygroscopic water	1.50	per cent.
Water (combined) and CO_2	5.51	"
SiO_2	60.55	"
Al_2O_3	14.79	"
Fe O	7.58	"
Ca O	1.81	"
Mg O	1.55	"

Rosedale Pressed Brick and Terra Cotta Co.

The Rosedale Pressed Brick and Terra Cotta Company, whose works are situated at the base of the high bank overlooking the river and a little farther down stream than the Taylors', have apparently a large supply of promising clay, and are also proposing to enter into manufacture of paving brick.

In the Humber valley.

Toronto Vitrified Paving Brick and Stone Co.

The Toronto Vitrified Paving Brick and Stone Company have a very conveniently situated property on the east bank of the Humber, at the point where Bloor street strikes the river opposite the old stone mill. The Hudson River shale outcrops in the bank of the river and rises there perhaps 20 feet above the water. As the property extends over a number of acres there is a plentiful supply of the raw material. The shale is here interbedded with bands of calciferous sandstone of varying thickness, which would have to be laid aside in the working.[11] Shipments of brick could be made either by means of scows (the river affording a depth of 12 feet of water) or by rail, a switch of the Belt Line railway running into the property. A large building has been erected, some of the machinery put in place and two kilns par-

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[11] A little higher up the river, on Mr. Baby's farm, there is a lofty bluff in which bands of shale and sandstone are exposed, and where quarrying operations could be carried on very economically. The river at this point has furnished an excellent building stone for many years, and every freshet brings new supplies to the surface. North of the bluff a sand road makes the ascent of Toe-nail Hill to the old Indian burial ground, so well known to local antiquarians.

Analyses.

tially completed, out of a plant intended eventually to produce 50,000,000 bricks a year, but the recent financial depression has obliged the company to cease operations, and at present progress is suspended. Analyses by Dr. Coleman and Prof. Heys of the shale give the following results, which seem to show that it is not the same in quality throughout:

I. (Dr. Coleman).

Hygroscopic water	1.24	per cent.
Water (combined) and CO_2	6.07	"
$Si\,O_2$	63.47	"
Al_2O_3	11.28	"
$Fe\,O$	6.90	"
$Ca\,O$	3.30	"
$Mg\,O$	2.20	"
K_2O	3.41	"
Na_2O	2.60	"
	100.47	"

II. (Prof. Heys.)

Silica	55.28	per cent.
Alumina	24.29	"
Oxide of Iron	6.82	"
Lime	1.68	"
Magnesia	.80	"
Carbonic acid	1.31	"
Sulphuric acid	1.25	"
Moisture and organic matter	6.57	"
Alkalies and loss	2.00	"
	100.00	"

At Mimico.

Mimico Sewer Pipe and Brick Manufacturing Co.

At the Mimico Sewer Pipe and Brick Manufacturing Company's works, Mimico, the Hudson River shales come to within a few feet of the surface. Immediately below the soil is a deposit of yellow clay about three feet thick, of suitable quality for mixing with the shale in the manufacture of sewer pipe, and below this is a bed of gray calcareous clay of the thickness of a foot. Immediately underlying the latter is the shale, which here as elsewhere is interbedded with bands of limestone. This company is engaged chiefly in the production of sewer pipe, but has also been experimenting with its material with the view of making vitrified brick. Some excellent samples have been produced. An analysis of the shale by Dr. Coleman shows it to have the following composition:

nalysis.

Hygroscopic water	1.34	per cent.
Water (combined) and CO_2	6.08	"
$Si\,O_2$	58.18	"
$Al_2\,O_3$	15.47	"
$Fe\,O$	7.42	"
$Ca\,O$	2.61	"
$Mg\,O$	2.98	"

Medina.

The red Medina shales, which have seldom a less thickness than 500 feet, are already utilized on a considerable scale by various firms in the manufacture of pressed brick, terra-cotta and tile, at Milton, Beamsville, Terra Cotta and elsewhere. At Hamilton they furnish the Hamilton and Toronto Sewer Pipe Company with the raw material for excellent sewer pipes and building brick, and the company are now proposing to add to their extensive business the manufacture of vitrified brick. Their works consist of two distinct plants, one of which is not at present in use, but is likely to be made the scene of the new industry. A mixture of 50 per cent. shale and 50 per cent. clay is used for the sewer pipe, and a like mixture will probably be employed for the paving brick. The clay is simply disintegrated shale and is found immediately at the base of the mountain, where the shale in place outcrops

Hamilton and Toronto Sewer Pipe Co.

edina sandstone, as well as overlying the greater part of the level een the mountain and the bay. A quantity of the raw material Canton, Ohio, and manufactured into paving bricks there. An e mixed clay and shale ground ready for use, made by Dr. s follows :

Analysis.

(combined) and CO_2	4.17	per cent.
	61 79	"
	14 53	"
	8.35	"
	0.85	"
	2.28	"

being wet, was dried at 100° c. before weighing ; and as it was he iron was determined as Fe_2O_3 .

ilding-brick manufactory on the outskirts of Toronto Junction, Dinnick is adding a plant for making vitrified brick. The raw h Mr. Dinnick proposes to use is a mixture of the red Medina y, and after considerable time and money spent in experimenting e has discovered the proper proportions in which such a mixture best results. The samples he has produced from his own kilns of good quality.'

The pressed brick industry.

TESTS OF ONTARIO PAVING BRICKS.

bricks from some of the shales and clays of Ontario mentioned ecently subjected to a test at the School of Practical Science, Mr. C. H. C. Wright, B.A.SC., lecturer in Architecture, the object rmine (1) their powers of absorbing moisture, and (2) their transh. The bricks so tested were made from the Hudson River Don and Mimico, and the Medina shale and clay at Hamilton. hese were submitted for purposes of comparison several bricks of anufacture in the United States. The results were highly gratify at the present experimental stage of the industry here, when expected that the best methods have been found or the greatest ulation acquired. The test was indeed surprisingly favorable o bricks, goes far to show not only that we have here the right hich to base the manufacture, but also that Ontario makers h time and experience to produce an article which will withstand rom any quarter. In ascertaining the powers of absorption of mples, or rather their capacity to resist the penetration of water, re placed in a drying chamber and subjected to heat until they weight, thus depriving them of all their hygrometric moisture. en immersed in water, and weighed at intervals of three, five days, with the results as noted in the respective columns of the elow. It will be observed that much the larger proportion of p was in every instance during the first period of three days, e was comparatively little increase in weight after the fifth day. tion test the Syracuse brick, which proved itself almost imperr, took first place, the Ontario samples ranking second, third and howing a marked superiority over two of the American bricks. n of high non-absorptive properties in a brick is good evidence of ification, and is a prime requisite in a climate like our own. In nes.)

Tests at the School of Practical Science,

with U.S. and Ontario paving bricks,

for absorption

more southern regions, where the temperature is uniformly higher, this quality probably has not the same importance, but the effect of our keen frosts on a pavement of water-soaked brick would be very disastrous.

and transverse strength.

The transverse strength of the bricks was preferred as a test to their crushing strain, which is the one usually taken, for two reasons, (1) it is more likely to be a true index of the quality of the brick, and (2) it more nearly represents the conditions of actual wear. In the usual method of ascertaining the crushing strain a one or two-inch cube is cut from a corner of the sample and subjected to the test. In hammering, chipping and otherwise dressing this small cube to the perfectly exact dimensions required, there is considerable risk of weakening it by starting flaws or cracks, not discernible to the eye, yet of sufficient importance to vitiate the result of the test. This objection does not apply to the test for transverse strength, which is made on a machine constructed for the purpose by placing the specimen on rests near the ends and then applying pressure in the centre until it gives way. The weight registered by the machine at the instant of yielding is the total pressure applied, from which the pressure sustained per square inch is easily calculated. A pavement is very rarely called upon to withstand anything like a pressure of 10,000 or 12,000 lb. per square inch, which is about the crushing strain capacity of good paving brick, and in any case it is evident that the wear due to dead weight pressure is very small as compared with that caused by inpact and friction. The transverse strength test, on the other hand, indicates the power of a brick to resist pressure and at the same time to withstand the flattening-out or stretching tendency induced by a superincumbent weight. In this test the Syracuse brick again headed the list, the Ontario samples standing second, fourth and sixth. The average transverse strength shown by the seven samples was 2,659 lb. per square inch, while the average of the three Ontario bricks was 2,681 lb. per square inch. Good quality paving brick is expected to stand a transverse strain of not less than 1,600 lb. per square inch, so that every one of the samples tested was more than equal to the requirement in this respect.

The bricks experimented upon were from the following Ontario manufacturers, viz.: Hamilton and Toronto Sewer Pipe Company, Hamilton; Taylor Bros., Toronto, and Mimico Sewer Pipe and Brick Manufacturing Company, Mimico; and from four well-known firms in the United States, in Galesburgh, Ill., Syracuse, N.Y., Canton, Ohio, and Cumberland, W. Va.

Table of absorption test.

The following table shows the result of the test for absorption:

Brick No.	Weight in pounds.				Total increase. lb.	Percentage of increase.
	Dry.	3 days in water.	5 days in water.	14 days in water.		
1	6.908	7.000	7.027	7.047	.139	2.01
2	7.344	7.375	7.375	7.375	.031	.42
3	6.078	6.094	6.098	6.109	.031	.51
4	5.984	6.078	6.094	6.109	.125	2.08
5	4.625	4.625	4.627	4.627	.002	.04
6	7.000	8.068	8.738	8.750	1.750	25.00
7	6.891	7.862	7.987	7.901	1.010	14.65

Table of transverse strength test.

In the test for transverse strength the bricks were placed on edge, or with the narrow side up; and the usual formula for determining the modulus of rupture was applied, viz.: $f = \frac{3wl}{bh^2}$, where w = centre load in lb., $l = \frac{1}{2}$ span in inches, b = breadth, and h = height. The following table gives the results, and also the size of the bricks in inches:

Brick No.	Transverse strength lb. per sq. inch.	Size of Bricks (inches).
1	1,793	2.525 x 4.050 x 8.500
2	2,549	2.600 x 3.900 x 8.750
3	3,703	2 375 x 3.875 x 7.750
4	3,134	2.325 x 3.850 x 8.125
5	3,972	2.000 x 3.650 x 7.500
6	1,948	2.560 x 3.750 x 8.500
7	1,515	2.500 x 4.250 x 8.500

THE CLAY WEALTH OF ONTARIO.

The enormous value which lies latent in our vast deposits of clay is as yet but faintly realized. A beginning has been made in their utilization by establishing the manufacture of pressed brick. This industry is hardly more than six years old in Ontario, and already it has proved a source not only of private gain, but of public benefit on a large scale. Employment has been furnished to the workingmen of our Province, for the processes through which the clay must be put before reaching the stage of the final product require the assistance of many hands, and to this extent the necessity of leaving our country to seek work elsewhere has been lessened. One more avenue has been found for the employment of capital at home, and it is no less important to check the exodus of capital than that of labor. Capital is the stream, labor the wheel which it turns; "useless each without the other." We cannot continue to send our surplus capital to be employed in enterprises outside of the country without at the same time sending thither our laborers to assist in the application of it. Capital and labor flow along the line of least resistance, and both will find their way to the place where they can secure the greatest return. But a current of either capital or labor once established in a particular direction is difficult to divert except by the certain prospect of profitable employment nearer the starting place. The pressed brick industry of Ontario has given an instance of how such a diversion may be effected. Large manufactories have been built, large sums of money expended in establishing them, large amounts have been and, notwithstanding the present depression, are still being annually paid as wages to workmen, and to railways for transportation. These are the results to private individuals directly interested in the business. But the public as well has been benefited. Building material of superior quality has been furnished those who wished to erect houses, and the use of pressed brick and terra cotta in our cities and towns has added very largely to the beauty and durability of recent architecture. The old roughly-made, soft-burned and easily disintegrated bricks have given place to well-formed, hard-burned, dense articles, far superior in lasting qualities, at a cost not actually much greater and indeed much less in proportion to their value.

Employment of labor and capital at home.

Paving brick industry.

An open field for enterprise.

There is a still larger field standing open for the manufacture of paving brick, and even greater benefits will be conferred upon the public by its introduction than in the case of pressed building brick. Vitrified brick is fast assuming the first position on the list of paving materials in the United States, and it is coming more and more into use as its merits become known. We in Ontario cannot long remain behind our neighbors; and indeed the chief if not the only obstacle in the way of its adoption here is the excessive cost induced by the expense of bringing the material from the other side. If the attempts being made to produce a first-class article from our own clays prove successful, this difficulty will to a large extent disappear, for the cost of manufacturing here ought to be little if at all above the cost of manufacturing in the United States, and vitrified brick of Ontario manufacture should sell as cheaply, or nearly so, as that of Ohio or Illinois does in those States. The market is that of the towns and cities of the Province, of neighboring Provinces, and perhaps—if production can be sufficiently cheapened—of neighboring States also. There is no danger of an exhaustion of the market, for so long as man maintains his gregarious habits, so long will there be cities and towns with streets to be paved and re-paved; and as taste improves and higher standards are set up people will demand the best, particularly if the best can be supplied at a moderate cost. The first manufacturers will have the field to themselves, for there is a substantial impost on the imported article, and even without it the freight on a thousand of Ohio paving brick is almost equal to the prime cost, and quite sufficient to give the home manufacturer an indisputable advantage in the markets of his own Province.

The benefits of well paved streets.

The immense benefits which well paved streets would confer on the inhabitants of our towns and cities can hardly be estimated. Every working horse, every buggy, delivery wagon or dray would have a longer life; larger loads could be taken and consequently the cost of hauling and delivery would be lessened; no longer would rainy weather and the wheels of traffic churn the surface of streets into eye and nose-offending mud; time would be saved by the increased rapidity with which distances could be traversed; frequent and expensive repairs would be obviated; and the public health would be improved, for the streets could be readily and cheaply cleaned and no excuse would exist for allowing disease-breeding filth to find lodgment under the public gaze. The establishment in our Province of a paving brick industry is calculated to bring about such a state of affairs. It would afford employment for labor and capital. It would be another step in the utilization of our dormant resources, and a distinct advance in national progress and development.

T. W. G.

VI.

ROCKS AND BUILDING STONE.

By Dr. A. P. Coleman, Toronto.

Rock or stone.

Geologists and architects have at least one interest in common, they both deal in what a geologist calls “ rocks ” and an architect ‘ stone.” The rocks of the geologist include however the sand of a seashore, the soil of a field and the ice of a glacier, whereas no architect would think of building in any of these materials unless perhaps an ice palace at Quebec, Montreal or Ottawa, this or some other winter. The geologist, when dealing with rocks, is apt to dub himself a petrographer or lithologist, but the architect is more modest and gives himself no special name because he builds in stone.

Divisions of rocks.

The petrographer divides rocks into three grand divisions,—massive or igneous rocks, resulting from the cooling of melted material; schistose rocks, having their minerals arranged in a parallel way so as to split most readily in one direction; and sedimentary or clastic rocks, made of fragments of other rocks deposited by water. The massive rocks show the greatest variety of minerals, and are always taken up first. Their mineral constituents are of two kinds,—essential, when their absence would throw the rock into another species, and accessory, when less important.

Mineral constituents of rocks.

The mineral playing the largest part in the formation of rocks is quartz, rock crystal when it displays its own form, a six-sided prism ending in a pyramid. It is the hardest of the essential rock-forming minerals, is almost unattacked by the weather, and therefore is the most useful constituent of many stones suitable for building. Next in importance come the felspars, orthoclase with its flesh red or white cleavage surfaces, and plagioclase showing delicate striations on cleavage planes. The former is a silicate of alumina and potash, and the latter of alumina and soda or lime Some of the plagioclase felspars have a magnificent play of color, as in labradorite. Of the darker rock minerals, mica, hornblende and augite are most important. There are several kinds of mica, but we need mention only muscovite, a silicate of potash having pale colors, and biotite, a magnesian silicate very dark in color. All micas may be recognized by their very perfect cleavage into exceedingly thin elastic plates. Hornblende is a dark colored silicate having two planes of cleavage with an angle of 124° between them. The scales cleft off are not elastic. Augite or pyroxene, another dark, almost black silicate, has usually no distinct cleavage, and may be distinguished thus from hornblende. Of the accessory minerals, few are of much interest to us, though garnet, often of a fine red color, occurs in many archæan rocks in Ontario, and tourmaline in black triangular prisms may sometimes be seen. The most important of the accessory minerals to the architect is iron pyrites, a hard, brassy looking sulphide of iron crystallizing in cubes, which under the action of the weather may change to a sulphate and finally stain the rock where it occurs rusty brown with oxide of iron.

Massive rocks.

Granite, syenite, diorite, and gabbro.

Turning now to the rocks themselves, granite is naturally taken up first by both petrographers and architects, as the most widespread and useful of the group. It consists essentially of quartz, felspar and mica or hornblende, and takes on gray or flesh red colors from the prevalent orthoclase felspar. It is one of the handsomest and most durable of building stones, and but for its great hardness would no doubt come into much wider use. Its one defect is the ease with which it crumbles under the action of intense heat, as shown at the Boston fire. If quartz be omitted from granite, the rock is called syenite, which has the same colors and uses as the previous rock, though a little softer to work. When the felspar is striated and mixed with hornblende, forming a dark green or black rock, it is named diorite; if augite is the dark mineral the rock is diabase or gabbro. All these rocks fall into the same line in the hands of the builder, who sometimes calls them black granite.

Porphyry.

Porphyries are rocks unlike those that have been described in that the general mass is fine grained or compact in structure, enclosing larger grains or crystals of quartz or the felspars. Some of the porphyries are very handsome stones for ornamental work, but are little used in building.

The more important ancient massive rocks have now been described, and it will scarcely be necessary to take up in detail the corresponding series of modern eruptive rocks, including the lavas, such as trachyte and basalt.

Schistose rocks.

Gneiss.

The schistose rocks too need only a brief mention, since only one of them, gneiss, practically granite, having a parallel arrangement of its mica plates, is used to any extent for building. In Norway one sometimes sees a whole house built of gneiss, roof as well as walls.

The sedimentary rocks.

Far more important are the fragmental or sedimentary rocks, which provide the most commonly used building stones. We may divide them into three groups, those made of clay in some form, those made up of silica or the silicates (quartz, felspar, etc.), and those which consist of carbonate of lime, or of this with carbonate of magnesia.

Slates.

The clayey or argillaceous rocks are usually too feeble and easily acted on by the weather to be of use in building. The slates however, which are clays consolidated and metamorphosed, are an exception, since innumerable minute crystals of mica and other minerals have begun to form in them, binding the materials together and giving a resistance to the weather surpassed by no other rock. The perfect cleavage which gives slate its value as roofing material does not correspond to the stratification, as one would expect, but has been caused probably by strong lateral pressure in mountain building. The different tones of color in slates are taken advantage of by architects to give variety in roof effects.

Sandstones.

Perhaps the most useful group of rocks in architecture is that of the sandstones. Breccias, made up of large angular fragments, are too rare to find much place as a building material; and conglomerates, formed of rounded pebbles cemented together, are also rarely put to use, though some notable buildings, such as the Pitti palace, are built of them. Our brilliant jasper from Lake Huron with its red pebbles on a white ground might effects, though it would be very hard to work. It would pro- eternity however, if put into a building. Sandstones, on the e among the most favored building materials. They consist ns of quartz, often with a large admixture of fragments of er silicates, and result from the destruction of the older massive ement binding the particles together has a great effect on the he stone, and should receive more attention than it does from siliceous cement forms a rock difficult to work, but lasting ever. A ferruginous cement consisting of oxides or carbon- a durable one, and occurs in many reddish or brownish sand- cement is said to be calcareous when carbonate of lime is ween the sand grains. Such sandstones effervesce with cold d the lime is more or less easily attacked by rain charged with from the air of cities, allowing the stone to crumble, The least t of all is argillaceous or clayey, and sandstones containing it egrate when exposed to the weather in a climate like ours. The hen breathed upon affords a rough test for the argillaceous an unhappy fact that the durability of a sandstone is often in o the ease with which it is worked, so that the builder is tempted rer qualities.

Carbonates.

e the carbonates, consisting of calcium carbonate in lime- of calcium and magnesium carbonates in dolomite. The distinguished by the action of cold acid, which effervesces the carbonate of lime, but hardly at all with dolomite. s are generally formed of broken shells, though in many com- , such as lithographic stone, the fossils have completely dis- orous modern limestones, formed by springs, are called travertine. cient limestones have been so metamorphosed as to become ystalline, and when very fine grained and pure white are les. Many of the colored varieties of so-called marbles are r uncrystalline limestones. The limestones are often admirable s, durable and handsome, but are apt to be attacked by the great cities charged with acid fumes. The dolomites resist this hat better. A very handsome variety of chemically deposited ime, sometimes used for interior decoration, is called Mexican trade, though incorrectly, since the true onyx is a variety of

Limestone and dolomite.

Coloring matter of rocks.

ng matter of rocks is usually some compound of iron. Reds are sesquioxide, hematite; browns and yellows by the hydrous or Red and brown sandstones are good examples of this; the paler less oxide of iron they contain, while pure white ones are practi- m this metal. The flesh color of orthoclase felspar in the granites m the red oxide of iron. On the other hand, silicates and other iron in the monoxide state show various shades of green or st black, as in the diorites and other greenstones, in green eenish gray sandstones. These green monoxide compounds of iron tend to weather into the ruddier sesquioxides. One often notices that pale greenish sandstones turn yellowish or brownish on exposure, a result of slow oxidation of ferrous oxide. The darker limestones are usually colored with bituminous or coaly matter, which on exposure gradually oxidizes; so that a blue limestone eventually bleaches to a pale gray, almost white.

Weathering quality of rocks.

The weathering quality of rocks is a matter of great interest to architects, for on this turns the permanence of their work. Certain rocks, such as quartzites and sandstones with a siliceous cement, are practically indestructible by the weather, as one can see on surfaces scoured by glaciers during the ice age seven thousand years ago, but still showing the polish and scratches then given them. Rocks formed of silicates, like granite and syenite, are also very resistant; others, like the limestones and marbles, are slowly dissolved by rain and are more rapidly acted on by the impure air of large cities, which contains traces of sulphuric acid. The dolomite of the English Parliament buildings is said to be suffering badly from this cause. Sandstones with clayey cements are readily disintegrated in moist and changeable climates; and stone containing much iron pyrites should be looked on with suspicion, since it is very apt to weather into brown oxide of iron, weakening the stone and giving rusty stains. The porosity of a stone is a matter of prime importance in a climate like ours, where water-soaked walls may be quickly crumbled under the action of frost.

Effects of cold and heat on rocks.

In rocks composed of several different minerals, like granite, great changes of temperature tend towards disintegration through unequal expansion. Quartz has a cubic expansion of .000036 for one degree centigrade; orthoclase, only seventeen parts in a million. In case of a great fire, where the temperature may be raised suddenly 1,000° or more, this unequal expansion sets up strains which split off the surface, as in the great fires of Boston and Portland, where massive granite buildings crumbled to ruins. One would expect limestones to burn to quicklime and thus fall to pieces, but actually they resist far more heat than granite, while sandstones resist fire best of all.

The testing of rocks.

The last point to be referred to is the best means of testing a rock intended for building purposes. The test of time is of course the most convincing of all, but then one cannot always wait a thousand years to see how durable a building stone is. The resistance of a cube of stone to crushing strain gives useful evidence as to its strength, and the amount of water it absorbs helps to a decision as to its durability in frosty climates; but the most valuable test of a scientific kind is a petrographical examination. By the microscopic study of thin rock sections one can determine the actual minerals that make up a rock, their relationship to one another, their state of freshness or decay, and the character of the cement that binds the particles together. No other method will give such complete evidence as to the internal structure of a rock, on which its durability depends, as a careful examination of sections under the microscope.

VII.

LITHOGRAPHIC STONE.

Volney's quarry.

port of the Bureau for 1892 an account was given of the opening of a quarry of lithographic stone by Dr. Volney of New ow lake, in the county of Hastings. This quarry is on the as McGraw, and consists of fifty acres, being part of lot 9 in the on of Marmora, on the south side of Crow lake. A small mill ed near the quarry for dressing the stone, and samples sent to said to have proved very satisfactory. Dr. Volney hopes to npany to undertake operations upon a larger scale.

North American Stone and Asbestos Company's quarry.

e west of the Volney quarry a new property was opened last ill was built to dress the stone for market. This locality was 1892, and in December of that year or in January of 1893 a npany known as the North American Stone and Asbestos Com- nized to carry on operations. The capital is $200,000 ; George ew York city is president, and A. M. Chisholm of the same of Marmora, is general manager. Samples of stone taken in een tested in New York, the Company proceeded to acquire the on an area of 313 acres, consisting of 165 acres owned by Wil- arts of lots 6 and 7 in the third concession, 135 acres owned onter, parts of lots 7 and 8 in the third concession, 8 acres mas McGraw, part of 8 in the third, and 5 acres owned by Pat- n the second concession. The consideration paid was $4,800. f last year work was commenced by opening a quarry on lot 7 ncession, close to the south shore of Crow lake, and about the erection of a mill was undertaken. The ground where the pened is ten feet above the level of the lake, and the rock only a few inches of drift. The formation is Trenton lime- enly bedded, but showing a slight dip to the southeast—about 100 feet. A hundred yards from the lake the ground begins to n old shore line. The quarry is 100 feet long by 50 wide, and ed to a depth of 25 feet. The jointings are in straight lines, and rt for blocks to be taken out of any size that is likely to be e first layer of lithograph stone is 7 feet from the surface, and s of 10 inches. It is marked with a white cloud, and is not of re. Three inches below it is the second layer, 7 inches in thick- rd layer has a thickness of 16 inches, the fourth 12 inches, the , and the sixth, seventh, eighth and ninth from 6 to 8 inches. rs are separated from each other by beds of limestone ranging nches in thickness, and suitable for building stone. The several

The quarry.

layers below the first differ from each other more or less in color and texture, one being of a dark cream color, and the others of varying darker shades from gray to blue. The fifth is a dark blue stone, but very fine in texture. Owing to the nearness of the quarry to the lake, there was a constant flow of water into it between the beds after the lake level was reached; but with a pulsometer pump no difficulty was experienced in keeping the water under control.

The mill.

The mill is a frame structure, 35 by 88 feet, with an engine and boiler room attached, 20 by 24 feet. The boiler is 120 h.p., and the engine 95 h.-p., built by Hamilton of Peterborough. Two gangs of saws have been set up in the main building, the saws being of common band iron. Sand is fed to them automatically, and water is supplied from an overhead tank. The planer is of Brooklyn manufacture, and has a bed area of 36 by 52 inches. The cut of the saws is at the rate of 1½ inch per hour, and as they are run night and day when the mill is in operation, their capacity is 3 feet per day. The mill was started about the first of June, and operations were continued to the 10th of November. During this time twenty men were employed at the works, fifteen in the quarry and five in the mill and blacksmith's shop.

Tests were made in New York with 45 stones from the several layers and all except those from the top one were pronounced "O. K. and all right." These stones were from 20 by 30 inches up to 36 by 52 inches; but stones have been taken out 6 feet square without a flaw. The demand is for the larger sizes.

It is the intention of the Company to add to the sawing and planing capacity of the mill and possibly also to manufacture vitrified brick. The top layer of the lithographic stone appears to be well adapted for the latter purpose with the addition of other materials, as shown by samples made in New York.

Kelly's property.

Another location of lithographic stone is lot 9 in the fourth concession of Marmora, the property of Mr. William Kelly of Marmora village, who purchased it from Hon. Malcolm Cameron in 1870. A Detroit syndicate procured an option on this lot last year, and at the time of my visit to Marmora in the latter part of November prospecting operations were being carried on upon it under the direction of Mr. Wayne Choate, a mining engineer from Detroit. The top layer of lithographic stone has a thickness of 10 inches; six inches below it is a second layer of 30 inches, and a foot below the second is a third of 18 inches. The middle one is lightest in color and the best in quality. The same bands of lithographic stone are seen to outcrop on the banks of Crow river, at the village of Marmora, but the stone there is marred with fine crystals of calcite.

Old quarry on Crow river.

In 1862 or 1863 an American company built a mill to manufacture lithographic stone at a point lower down the river, on lot 6 in the fourth concession; but the quality was not suitable. The property was afterwards bought by the late Judge Sherwood, and by him sold to Mr. Kelly. The area of this location is only one acre.

VIII.

MOSS-LITTER.

By Edward Jack, Fredricton, N.B.

The introduction of moss litter as an article of manufacture and commerce.

The application of moss as bedding for horses and cattle is of ancient date, especially in Sweden, where the inhabitants who resided near the moors have made use of it for a long time in a small way. But it was only in the year 1880 that moss-litter was made an article of manufacture and commerce, and this was done by Hollman, at Gifhorn in Hanover. Torf mull (turf dust) had also previously to this time been made use of in Sweden, on a small scale, as a deodorizer in closets. In what the Germans denominate high moors, water mosses take the most important part, especially the sphagnum, of which we have very many varieties in Canada. This is usually the predominant plant so long as the moor continues growing; where this growth from whatever cause ceases, either on the whole or in places, heath plants, such as Cassandra, Andromeda, Kalmia and Ledum spring up.

Absorptive property of turf.

That property which renders turf most suitable for the purposes of litter is its absorptive power, which varies much in different kinds. While some kinds of turf in an air-dried condition, containing 20 per cent. of water, will absorb but twice their own weight of fluid, there are others which take it up even to twenty times their own weight. This difference is owing to the structure of the turf, and in part depends upon its botanical constitution, as well as on its degree of decay. The more the turf is decayed the less quantity of fluid is it able to absorb. The bright, light, fibrous, but little decayed turf, which forms the upper layers of many moors, has a much greater absorptive power than the dark heavy turf, which is much better however for use as fuel.

The sphagnum mosses.

But the botanical composition of the turf is of more importance than the degree of decay. The moors which are formed by the growth and decay of the various sphagnum mosses occupy the first place as a source of supply for moss-litter. The remarkable absorptive power of these mosses depends upon the peculiar structure of their cells, which is found in but few others. The leaves and epidermis of the stalk are very largely composed of large empty cells, which can fill themselves with water by means of a number of holes. The cell walls are prevented from collapsing through the ring or spiral-formed thickenings with which their inner sides are provided. They are thus always distended, and thus always ready for use. Between these cells lie smaller ones, which contain chlorophyl and afford nourishment to the plant. They take up however but a small space. This capillary apparatus enables the sphagnum plant to raise the water to its highest parts, even when these are above the water level. By the felting of the moss there is also formed, so to say, a net of water-absorbing channels which act in the like manner.

Experiments at Jonkoping.

The absorptive power of the turf is also dependent on the fineness of its division. Von Feilitzen made some experiments on the subject at the experimental station at Jonkoping in Sweden, the results of which were as follows:

1. The turf broken up by hand into large pieces took up 16.36 times its own weight of water.

2. After the turf had been passed through a sieve with one and a half millimetre mesh it took up 18.83 times its own weight of water.

3. Using a sieve of a mesh of one-half a millimetre, only 14.08 times its own weight of water was absorbed.

A simple test for ascertaining absorptive power.

Since the value of turf used as a moss litter depends in so great a degree upon its absorptive power, which again is dependent on its dryness, it is very necessary that one should have some simple way of ascertaining this, for moss-litter containing 30 per cent. of water seems to the touch to be dry. In order to make this test, all one has to do is to weigh a sample and allow it to remain for three days in water. It is then placed on a sieve which had been previously weighed, and the superfluous water allowed to drain off in a cold room where there is but little evaporation taking place. The difference in weight, deducting that of the litter in its original state, will give the absorptive power and consequent value of the article. The writer found by such a trial that the absorptive power of the sphagnum moss taken from the great moor at Shippegan, in the county of Gloucester, New Brunswick, was seventeen times the weight of the original moss, which had been previously dried artificially. The absorptive power which can be profitably made use of must be below that number, for the very act of removing this specimen from the sieve caused a large loss in the water which it had absorbed.

Absorption of gases.

The sphagnum moss has not only great absorptive power in so far as water is concerned, but also as respects gases. Its absorption of ammonia is in part due to the free humic acid which may be found in connection with the litter; but according to experiments carried on at the Experimental Moor Station by Dr A. Koenig the ammonia was arrested chiefly by the pores of the plant.

Experiments at Hanover with moss and straw.

An experiment made by the regimental veterinary surgeon Arnold at Hanover on the purity of air in the stables where moss-litter was used for bedding, shows this absorptive power for gases well. The moss-litter used was strewed to the thickness of twelve centimeters, the air was examined daily, and its contents of ammonia ascertained. The result for six days showed the gas contents in a given quantity of air each day to be as follows:

	Where moss-litter was used.	Where straw was used.
Day.	Gram.	Gram.
1	0.	0.0012
2	0.	0.0028
3	0.	0.0045
4	0.	0.0081
5	Trace.	0.0153
6	0.0010.	0.0168

While the much decomposed dark turf can remain long in the water without taking up very much of it, the brighter air-dried fibrous moss is a mos ready absorbent, and can take up just as much water as it was originally able to do. There is also a great difference in the absorptive powers of the various layers of the same moor. Experiments made at the Experimental Moor Station gave as the result of the absorptive power of the different strata of a northwest German moor at Osterholz the following numbers :

Depth of layer experimented on in centimetres.		100 parts of dried moor substance absorbed water in parts—
0—27	Much decomposed heath humus, passing over into much decomposed moss turf.....	890
27—43	Moss turf, with some remains of eriophorum, (a common bogplant in northern Canada ; the spike in fruit looks like a tuft of cotton.)	1,390
43—61	Clean undecomposed moss turf................	1,560
61—76	In part, much decomposed heath earth ; in part, little decomposed moss turf..........................	820
76—91	Mixture of heath earth, moss turf, and remains of eriophorum	720
91—104	Chiefly much decomposed heath turf, with a little undecomposed moss turf and remains of eriophorum....	570
104—117	The same......................................	590
117—131	Nearly amorphous heath turf, with a small quantity of undecomposed stalks of heather................	510
131—151	The same...	400
151—157	The same...	400

Procuring and preparing the turf.

It is a matter of prime importance that means should be taken to drain, so far as possible, any moor which is intended to be made use of as a source of supply of moss-litter. In some of the North German moors a simple and easy way of securing the material has been for some time in use. At the commencement of the winter the surface of the moor is ploughed to a moderate depth, and then allowed to remain over winter in order that the frost may act upon it, since the frozen turf dries quicker than that which has not been exposed to the frost ; and experiments have also proved that the moss which froze when full of water loses by thawing alone a considerable quantity of it. In the following spring these furrows are gone over with a harrow, and in dry weather they are repeatedly harrowed with a lighter harrow. So soon as the first layer appears to be sufficiently dry it is removed ; the harrowing, drying and removal are again repeated, so that this may be done in Germany as many as ten times during a very dry summer. In other cases the turf is dug or cut in pieces, or clods. These are then piled in conical heaps, a vacant place being left in the centre so that the sun and wind can have their full action on them. While the pure sphagnum affords much the best litter, it must be remembered that the remains of various other plants found in bogs are also used for such purpose. A specimen of German moss litter, such as is now being used at the rate of 50 tons per week in Boston, was sent the writer a few weeks ago ; no sphagnum plants were visible in it, and it was altogether inferior to moss-litter which can be furnished from Canada.

The preparation of moss-litter is very simple. The first operation is the breaking up of the sods, which is done in a machine called a Reisswolf, which is nothing more than a cylinder, inside of which there is a revolving roller, provided with bent iron teeth. By this means the clods are reduced to the proper size, and come out at the bottom of the cylinder. With this a shaking sieve is connected, which separates the moss-litter from the dust, or torf mull, an article which is now being made use of in Germany and elsewhere for many important purposes. The Reisswolf may be driven by hand, horse or steam power, according to the amount of work required to be done. The material thus reduced in size and separated from the mull or dust is introduced into a press somewhat similar to the American beater, where it is pressed into bales of about 1.25 metres long by 0.75 metres broad. Before its removal from the press it is protected at the angles by laths, and the whole firmly held together by four pieces of iron wire, two of these near the centre of the bale, while the other two are fastened around it near either end. From 50 to 60 of such bales constitute a load in Germany for a common railway car.

Mode of using the litter in the stalls.

In stalls of all kinds, as in the case of straw, the litter must be kept and applied dry. For a beast which is constantly in the stall a hundred weight of moss-litter per year should be allowed for each hundred of live weight of the animal; working beasts require less. The litter should be strewed to the depth of 12 to 15 centimetres; this may be allowed to remain untouched for a fortnight. If one would be saving, such part of the litter as becomes damp can be raked up under the crib to dry there, in order to be used again, but it is better to remove the wet litter and replace it by dry. About 75 kilograms are required monthly per horse; cattle, on account of their more watery excrements, require more. By the use of moss-litter the animals are provided with a suitable, soft, elastic and dry bed, they are kept clean, while the air in the stables is rendered pure, and lung diseases prevented. The most valuable part of the animals' secretions, which is nearly all lost by the use of straw, is completely saved for the agriculturist by means of the absorptive powers of moss-litter, and it has also been experimentally established by one of the leading veterinary surgeons of Berlin that in stables which were well provided with moss-litter there was 30 per cent. fewer cases of hoof lameness than in those which were not furnished with that material.

Value of moss-litter as a fertilizer.

Some experiments were made in Germany in the year 1883 in order to ascertain the difference between the value of moss-litter and straw as fertilizers after they had been used in the stall. With this object in view nine head of cattle were allowed to stand six days in a stall, where they were bedded with rye straw to a depth of from twelve to thirteen centimetres; during the next six days moss-litter was used for bedding. The analyses gave the following results in 1,000 parts of dry dung:

	With straw litter.	With moss-litter.
Potash	16.28	16.99
Lime	8.85	9.11
Phosphoric acid	7.91	8.33
Total nitrogen	15.12	19.63
Easily soluble nitrogen	0.31	2.14
Difficultly soluble nitrogen	14.81	17.49

In the autumn of 1884 further experiments were made in Germany on ten milch cows bedded in a similar manner, with the following results in 1,000 parts of dry dung:

	With straw.	With moss-litter.
Potash	16.3	15.4
Lime	5.4	5.0
Phosphoric acid	12.1	12.7
Total nitrogen	24.9	29.4
Easily soluble nitrogen	7.8	12.6
Difficultly soluble nitrogen	17.1	16.8

arkable increase in the amount of easily soluble nitrogen is a very eature in the above analyses. This easily soluble nitrogen which ed by the moss-litter was lost in the case of the straw, which escape in the ammonia, and circulating through the air of the red it unhealthy for the cattle which were compelled to live in it. xperiment on these ten cows it was shown that by using moss- l of straw for bedding about 140 kilograms of easily soluble nitro- his case saved in the course of year.

Uses of moss litter in towns.

towns where there are no proper systems of sewerage or drainage ten poisoned by the escape of gases from cesspools and places of eces; by the use of moss-litter and turf dust this could be avoided disagreeable odors could be transformed into a most valuable add to, instead of taking from, the comforts of man. The of fecal matter in cities or towns has been and is the chief cause and infectious diseases, and one may well conceive what a bless- l be were this waste matter rendered not only innocuous, but even he farmer and market-gardener as a most useful accessory to his zers. Notwithstanding all the care which can be taken in pro- contents of cesspools by means of stone and lime, various experi- shown that the soil under and around them is more or less per- ecal matters, and thus a nursery is formed for bacteria and other ro-organisms. Moss-litter, which possesses so strong an absorp- or gases as well as fluids, when rightly applied can be made to evil; for not only will it prevent the escape of noxious fluids and t will also check the growth of injurious micro-organisms. In ply the moss-litter in such cases, it must be broken up into small e being thrown into the cesspool. It has been estimated that

Use of moss litter for cesspools.

d weight of good moss-litter will absorb 1,000 litres of fluid, and e of a hundred weight of moss-litter for the absorption of the feces son per year will be enough on the average. It is most advisable e strewing of the litter after the pot has been emptied, and regular should be carefully attended to so soon as any bad odors are per- fter some time the contents of the pot are absorbed and can be ut, being as free from smell as common earth. Experiments or seven months in Germany, on the content in carbonic acid of he neighbourhood of a cesspool which had been treated with moss- ed that by the use of this article the carbonic acid had decreased per cent., the original content prior to the use of the litter, to ent.

ous German cities the use of moss-litter has been introduced, partly tory and partly in an optional manner. Were the fecal matter of towns thus preserved for the use of the agriculturist and market- he saving which would be effected can easily be shown to be That this can be done with a profit to the towns themselves has d by various instances in Germany.

Value of liquid manure.

ing to Professor Heiden an animal weighing 1,000 pounds live produce yearly sixty-four hundred-weight of liquid dejections, the value of which he estimates at thirty-five marks. More than two-thirds of this he says is lost under ordinary management, but by the proper use of moss-litter this can to a very great extent be prevented; but as the property of moss-litter to fix ammonia is not without bounds, the addition of a little kainite to it will check the escape of any surplus nitrogen, as will also that of wood ashes or ground plaster.

Preservative powers as packing material.

The preservative powers of moss-litter are due to its property of absorbing gases and moisture, thereby among other things checking the growth of bacteria. Instances are given by the German authorities where sea fish by its use have been transported fresh for a long distance and were received in good condition at their destination more than a fortnight after they were caught. Autumn pears packed in it are reported by the same authorities to have been as good early the next summer as when they fell from the trees. Potatoes also when packed in it all winter were perfectly fresh during the succeeding summer, showing neither rot nor any signs of germination.

Experiments in Canada desirable.

The writer knows of no experiments having been carried on in Canada to test these preservative powers of peat moss, but it would seem very desirable that such should be made. In case this were attempted the cleanest and brightest sphagnum litter should be selected, and in order to increase its efficacy it should be artificially dried so as to expel as much as possible of the water which the common air-dried moss contains. Some of these deposits of Canadian sphagnum are remarkably free from any impurities. The upper layer of the great Shippegan moor, which consists nearly altogether of the remains of plants of *sphagnum fuscum*, is so clean that the water squeezed out of the dead wet moss taken from a distance below the surface is not only perfectly transparent but also tasteless. The habitants when crossing this moor often dig a hole and quench their thirst with the clean cool water which flows into it.

Prospects of a market.

There can be no doubt that peat moss can be raised and dried as well in Canada as in Germany; that we have it in as great quantities and of as good quality here as there; and that were this industry once started we would not only be able to supply all the wants of our own towns, but also have a large surplus for exportation. Four or five years ago Rothbart estimated the annual production of this article in Germany at 1,300,000 hundredweight, part of which was used there, the balance being exported to England, America, and even to the East Indies.

In the preparation of this short article on moss-litter, the writer acknowledges his indebtedness to the German authorities, especially to Furst, Fleischer and Junger.

IX.

IRON TRADE OF THE UNITED STATES.

Condition of the pig iron trade in the United States.

For the week ending February 3, 1894, there were 130 furnaces in blast in the United States, producing 101,043 tons of pig iron. In the corresponding week of 1893 there were 248 furnaces in blast, producing 174,534 tons. The total production in 1894 to February 3 was 505,215 tons, and to the corresponding date in 1893, 872,670 tons. This shows a decrease of 367,455 tons in a little over one month, or about 42 per cent. The Engineering and Mining Journal says : "That the iron and steel trade has been and is still demoralized to an extent that was never before known since iron was first made in this country, is a stubborn fact well known to those engaged in the business. . . Prices for all descriptions of iron and steel, raw and finished material, are away below any prices that were ever dreamed of, and there is apparently no room for further reductions in rates without going below the cost of manufacture."

Pig iron production.

A bulletin of the American Iron and Steel Association shows the production of pig iron in the United States in 1893 to be 7,124,502 gross tons, being 2,032,498 tons less than in 1892. The following table gives production by half years for the last four years :

—	1890.	1891.	1892.	1893.
	tons.	tons.	tons.	tons.
1st half	4,560,513	3,368,107	4,769,683	4,562,918
2nd half	4,642,190	4,911,763	4,387,317	2,561,584
Totals	9,202,703	8,279,870	9,157;000	7,124,502

As compared with the first half of 1893 the production in the second half of that year shows a decrease of nearly 44 per cent., the largest semi-annual decrease in production of which there is any statistical record.

Production of Bessemer ingots and rails in United States.

The total production of Bessemer steel ingots in the United States in 1893 was 3,123,524 gross tons, against 4,168,435 gross tons in 1892, showing a decrease of 1,044,911 tons, or over 25 per cent. In the last half of 1893 the production was only 1,031,467 tons against 2,092,057 tons in the first half—a falling off of more than 50 per cent. The production of steel rails was 1,036,353 gross tons, being 424,379 tons, or 30 per cent. less than in 1892. In the first half of the year there was produced 704,240 tons, and in the second half only 332,113 tons. The production of Bessemer steel rails in the United States in 1893 was the smallest since 1885.[2]

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[1] The Engineering and Mining Journal, Feb. 3, 1894, pp. 114-115.

[2] The Iron Age, Jan. 25, 1894, p. 156.

Lake Superior iron ore production.

The Iron Trade Review publishes the following table, showing the quantities of iron ore from the several ranges of Michigan, Wisconsin and Minnesota, carried down by lake freight in 1892 and 1893:

Ranges.	1892.	1893.
	tons.	tons.
Marquette	2,666,856	1,829,053
Menominee	2,261,499	1,466,197
Gogebic	2,973,993	1,329,464
Vermilion	1,167,650	820,621
Mesabi	4,245	613,620
	9,074,243	6,058,955

Add all rail shipments of both years and the totals of production are 9,603,173 and 6,236,992 tons respectively—showing a decrease in 1893 of 3,366,181 tons, or 35 per cent.[3]

Penokee and Gogebic Consolidated Mines in the hands of receivers.

On 11th January, 1894, the Penokee and Gogebic Consolidated Mines passed into the hands of receivers by order of the Court at Madison, Wis. This company controlled what is known as the Colby group of mines, which includes the Colby, the Palms, the Tilken and Comet iron mines in Michigan and the Superior mine in Wisconsin, all on the Gogebic range. An action begun by the Farmers' Loan and Trust Company of New York to foreclose a mortgage of $1,000,000 on the company's property was the immediate cause for appointment of receivers. The mines could have shipped this year a million tons of ore, more than half of which is ready for delivery; but there is no market. The Penokee and Gogebic Consolidated Mines are consolidated at $6,000,000, and among the principal stockholders are the Rockefellers.[4]

Dunn Mine, Lake Superior.

The Schlesinger syndicate, operating the Dunn mine on Menominee range, Wisconsin, ran behind during the depression of last year, and among the obligations unpaid were $22,000 for royalties and $10,000 freight to the Chicago and Northwestern Railway. The leasehold, for which the syndicate had paid $80,000, was recently sold under the hammer and was bid in by the railway for $28.[5]

An iron town sold out.

Fort Payne, Alabama, has been sold at public outcry for $60,000. The purchase includes 30,000 acres of mineral lands, 2,000 town lots and various industries, including the rolling mill and furnace of the Fort Payne Coal and Iron Co. It is said that the private and corporate expenditures amounted to $5,000,000, and of the Port Payne Coal and Iron Co. alone to $2,000,000. Yet all this property has been sold for $60,000. The town was founded by New England capital in 1889.[6]

The Pittsburg iron workers.

As further evidence of the depressed condition of the iron trade in the United States is an approximate estimate, prepared by the Pittsburg Press, of the number of men in the main iron works employed in the Pittsburg district. It shows that out of 56,956 men employed by 68 firms reported when working full time, only 26,413 were employed at the beginning of the present year.[7]

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[3] The Iron Age, Jan. 25, 1894, p. 157.

[4] The Iron Age, Jan. 18, 1894, p. 100.

[5] The Iron Age, Jan. 18, 1894, p. 100.

[6] The Iron Age, Feb. 1, 1894, p. 230.

[7] The Iron Age, Jan. 18, 1894, p. 113.

X.

NICKEL STEEL FOR ARMOR.

The merits of nickel steel and all steel in dispute.

One of the most promising uses of nickel continues to be as an alloy with steel in the manufacture of armor plate. Yet the superiority of nickel steel is not so uniformly admitted as to make the general adoption of it by Governments certain. In the United States there is no doubt in the mind of naval experts that the nickel steel plate surpasses all others in capacity to resist attack; and although discredit has been temporarily brought upon it by the dishonesty of certain parties employed in the manufacture of plate, there can be no doubt that a high degree of perfection has been attained in that country in the production of an alloy possessing admirable qualities. This is especially true of the nickel steel plate produced at the South Bethlehem works, as has been proven many times over by the severe tests to which it has been subjected. On the continent of Europe also, much attention has been given by Government officials and the heads of great iron and steel works to new processes of alloying and treating the metals; but perhaps with the single exception of the Krupp works in Germany the degree of success reached in the United States has nowhere else been attained. It is in Great Britain alone that claims are made of the superior excellence of all-steel plates, and the naval authorities of that country maintain that steel treated by the Harvey process has given even better results than nickel steel subjected to like treatment. It may be questioned however if in alloying nickel and steel for use in the manufacture of armor the quality is equal in all respects to the product of United States works. American experts assert that it is not, as has been shown by trials of armor in the two countries, and claim furthermore that the larger experience they have had in the manufacture and treatment of nickel steel entitles them to speak with some confidence upon its merits.

Ontario's interest in the subject.

The subject has an important interest to Ontario, because our nickel mines are one of the world's principal sources of supply of this metal; and being more accessible than their only rival, the New Caledonia mines, they are likely to profit most by every increased demand for the metal.

The situation of the controversy.

The papers which follow show pretty clearly the present situation of the controversy on the best material for the manufacture of armor plate. First in order is an extract from the Annual Report of the U. S. Secretary of the Navy for 1893. Then follows a paper by Mr. C. E. Ellis, (managing director of Messrs. John Brown & Co's Atlas Works), read at the British Institution of Naval Architects, 15th March, 1894, in which the records of numerous tests are given to show the excellence of all-steel armor treated by the Harvey process. Third in order is an extract from an editorial article in the

London Engineer of March 23rd, 1894, commenting upon the paper of Mr. Ellis and upon one read at the same meeting by William H. White, C.B., of the British Admiralty service, asserting the claim that "at the present moment England is taking the lead both in armor and ordnance." The fourth article is a reply to Engineer by Captain Jaques, Ordnance Engineer of the South Bethlehem Iron Works, which Engineer commented upon but declined to publish. By the favor of Captain Jaques it is published in this Report for the first time.

UNITED STATES TESTS OF ARMOR PLATE.

Tests at Indian Head proving ground.

"The tests of armor plates at the naval proving ground at Indian Head during the past year have been most important, some exceeding in severity any ever attempted either in this country or abroad. The results of these tests have been conclusive in demonstrating the desirability of using the Harvey process for the armor of all the vessels now under construction. In one test, that of a 14-inch nickel steel Harvey plate, the results were remarkable. Against this plate were fired four 10-inch Holtzer armor-piercing shells, with striking velocities of 1,472, 1,859, 1,959, and 2,059 foot-seconds, respectively. All four of these projectiles were crushed on the plate, the greatest penetration, which did not exceed 11 inches, being that of the last shot, which was fired at a fragment of the plate weighing but 4.4 tons with a striking energy of 14,715 foot-tons, or 3,344 foot-tons per ton of plate attacked. It is believed that such an energy per ton of plate has never been used in any test.

Tests of treated and untreated nickel-steel plates.

During the tests for acceptance of armor plates experiments have been made to determine the relative effects of impact of armor-piercing projectiles on ship's framing protected by ordinary nickel steel plates and by nickel steel Harveyized plates. In the experiments the backing representing the ship's framing was the same in each case.

The untreated nickel steel plates receive nearly all the energy within themselves, and distribute it over the vessel in racking effect, while the hard surface of the nickel steel Harveyized plates causes the energy of impact to be principally absorbed in the disintegration of the projectile. The experiments developed a marked difference in the effects produced, in one case a much heavier nickel untreated plate being set back bodily several inches under impact of 100 foot-seconds less velocity than the lowest striking velocity with which the Harvey plate was attacked, while the latter was scarcely moved at all.

During this year all the armor delivered has been of nickel steel, the tests of which have shown ballistic qualities decidedly superior to what is required for acceptance under the terms of the contracts.

Beneficial results of the Harvey process.

Exhaustive experiments have conclusively demonstrated the beneficial results obtained by the application of the Harvey process, and arrangements have recently been made to Harveyize such of the armor under the old contracts as was not too far advanced in manufacture to admit of the change, or as would not seriously delay the completion of the ships. In consequence of this, much of the side armor of the Maine, Texas, Indiana, Oregon and Puritan, the turret armor of the Maine, Puritan, and Monadnock, and the barbettes for the Oregon will be of Harveyized nickel steel. All the armor provided for under the new contracts will be treated by the Harvey process.

Adoption of nickel steel armor by European powers.

At the present time this country is no longer alone in the manufacture and use of nickel steel and nickel steel Harveyized armor, its initiative having been followed by many foreign powers. Compound armor has been abandoned by the German naval authorities, and that country will hereafter employ nickel steel, and it is believed that Krupp of Essen is using a surface-hardening process similar to that of Harvey. Nickel steel Harvey plates have been very successfully tried in England and Russia, and experiments are going on in France and Italy with a view to having its manufacture domesticated in those countries. The right to use the Harvey process has been secured by an Austrian firm, and the necessary furnaces are now being installed in that country. Nickel steel armor has been steadily growing in favor in England, and a syndicate, including the principal armor firms of that country, has purchased the right to use the Harvey process." [1]

Ellis on Recent Experiments in Armor.

At the meeting of the British Institution of Naval Architects in March the following paper was read by Mr. Charles E. Ellis of the armor-making firm of John Brown & Co. of Sheffield.

Armor plate and projectiles.

"The importance of any discoveries which will increase the defensive power of any given thickness of armor as disposed in modern battleships is so great that no apology is needed for introducing this subject to the Institution. By the kindness of the council I have been permitted to lay before the members a few remarks on the history of the latest developments of the attempts made by manufacturers to furnish a plate equal to cope with the improved armor-piercing forged steel projectiles, which at one time threatened to carry all before them. The adoption of a new type of plate for three important battleships by the British Admiralty has brought the entire subject into considerable prominence, particularly in consideration of the extensive shipbuilding programme, which is apparently admitted on all sides to be necessarily undertaken in this country.

COMPOUND V. STEEL PLATES.

Steel and compound armor.

"I think the last paper of importance which was presented to the Institution was that of M. Barba, the chief engineer of the Creusot Works, and was read in March, 1891. In that paper, and in the comments upon it made at the meeting, the merits and demerits of steel as against compound armor were fully discussed, and I think I am not going too far in saying that the general opinion was that for all practical purposes compound armor still held the field. It was felt that the acknowledged superiority of this type over steel in (1) offering greater resistance to projectiles of medium quality, as admitted by M. Barba himself, and (2) withstanding the attack of shot fired obliquely, was such that, in spite of the excellent results obtained both by Messrs. Schneider and by Messrs. Vickers in all steel plates, the compound plate was, under all the circumstances, preferable. The then recent tests on board the Nettle, which were under review at this period, are however valuable at the present time as forming a standpoint from which we can estimate the extent of later improvements.

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[1] From Secretary Herbert's Report for 1893, pp. 27-28.

Comparative tests of six years ago.

I take as examples the compound plate of Messrs. Cammell tested on March 24, 1888, and the steel plate of Messrs. Vickers tested on September 6, 1888. Each trial was made under the ordinary Nettle conditions. The plates measured 8 ft. by 6 ft. by 10½ in., and were attacked by the 6 in. breechloading gun, firing three Holtzer projectiles of 100 lb. in weight, and two Palliser shot of 98 lb., with a striking velocity in each case of 1,976 foot seconds, giving according to the Gavre formula a perforation in wrought iron of 11 in., and according to De Marre's formula of 13 in. The resistance of the compound plate to each of the Holtzer projectiles was about the same. Each of the shot stuck in the plate, being much split up, the base projecting in each case from 5½ in. to 6½ in. from the face, and bulges were formed at the back of the plate about 2 in. in height. The length of the Holtzer shot is 17½ in., and judging from the back of the plate and from the fact that the shot was somewhat set up, it is not unreasonable to suppose that the penetration in each case would be from 9 in. to 10 in. The plate developed several superficial cracks, but these were not at all serious. In the Vickers steel plate the penetrations were ascertainable in each case, being 13.5 in., 13 in., and 13 in. respectively, with bulges at the back of the plate from 2½ in. to 3½ in.; the projectiles rebounded entire, two of them being slightly distorted and set up. Three short through cracks were formed, but the plate remained entire. It is not necessary for my present purpose to consider the effect of the Palliser shots at these trials, beyond saying that each of the plates stood up well against them. I have taken these plates as favorable illustrations of the armor of the period—1888-91—when M. Barba's paper was read, and I shall now endeavor to show what increase of resisting power has been obtained in some of the later inventions or improvements in manufacture.

Cammell steel and nickel steel plates.

Dealing first with steel plates, I must refer to some trials of Messrs. Charles Cammell & Co., who, although fully occupied at the time with the manufacture of compound armor, achieved considerable success in their experiments with steel. Following up a successful trial of an all-steel plate at Portsmouth in May, 1888, they presented further plates for test in December, 1891, and in May, 1892, which were characterized by excellent quality of steel. Under the usual conditions of a Nettle trial each of the plates successfully stopped all the projectiles without any cracking whatever. The penetrations, as might be expected, were considerable, the greatest being about 14 in.; but there could be no doubt that a uniformly excellent plate had in each case been presented. The same firm was also successful in the manufacture of nickel steel plates, which were so largely used for the secondary armor of the Royal Sovereign class of battleship. The tests upon which these plates were selected were under the following conditions: The plate, 4 ft. by 4 ft. by 4 in., was not backed, and was attacked by er 5-in. projectiles of 49 lb. in weight, with a velocity of 1,200 ond. In the most successful trials none of the shot perforated d no cracks were found. For this class of armor there can be hat the alloy of nickel proved most beneficial in providing the ghness requisite when the plate is unbacked. My own firm ccessful at the same trials, which were competitive, in producing steel plates, and were allowed, with Messrs. Cammell, to proondary armor for the battleships above named!

Vickers plates.

llent plate, manufactured by Messrs. Vickers, was tested at Ochta r, 1890 ; but, as the results of that trial are so well known, I ive some particulars of the results achieved by the Continental rs in recent trials of steel armor.

Schneider plates.

I have no records of any of the plates of Messrs. Schneider hose which have appeared in the public press. I wish however he Texel trial of August, 1893, when this firm was represented. ns of the trial were the same as in the case of the Harveyed same trial. In the result Messrs. Schneider's plate was perfor- of the shots, but broke up two of the remaining three, one of fired with the highest velocity. The remaining shot, which was lowest velocity, rebounded intact. The plate, which appeared to ce hardened, exhibited no cracks whatever. Another interesting ickel steel armor of the same firm was held in the summer of last test plate for the armor being made for the Tri Sviatitelia was ful. The conditions of acceptance were that the plate should re- ows from Holtzer projectiles of 317 lb. from a 9.4 gun, with a ,945 f.s., without any portion of the plate being broken off, while as the base of the projectile allowed to penetrate the target to a much as 7.8. Through cracks were permitted. The plate ft. by 8 ft. by 15.9 in., and from the account in the Engineer mber, 1893) successfully passed these severe conditions, the etration being 14 in. No serious cracks were produced.

St. Chamond plates.

Chamond Company, in addition to some successful trials of Har- , which I will not deal with here, has been singularly success- oduction of a steel armor plate of great toughness and uniform nd I have the particulars of those trials where this is most ap- April and May, 1892, a plate measuring 8 ft. 3 in. square, and ickness, successfully withstood nine steel 6-in. projectiles weigh- ach, fired at a velocity of 2,149 ft. per second, without being d without any cracks whatever being formed, except in the bulges he projectiles. Judging from the two cases where it was pos- ure them, the penetration did not exceed $12\frac{7}{8}$ in. At the trial December, 1892, the same company exhibited a most interest- of this class of armor. The plate measured 8 ft. by 8 ft. by six shots weighing 87 lb. were fired at it from a 6-in. gun, at nging from 2,177 ft. to 2,198 ft. per second. The penetration $11\frac{1}{4}$ in. to 12 in., proving the uniform character of the steel, ks whatever appeared in the plate. The calculated perforation in wrought iron of the shot is according to the Gavre formula 11.7 in., and according to De Marre's formula 13.8 in. A further trial of a similar plate was made at Texel in August last, but as an account has so recently been given of the results in the Engineer (19th January, 1894), it is not considered necessary to do more than to say that the Ochta results were fully confirmed.

Chatillon Commentry plates.

Another French firm, the Chatillon Commentry Company, has devoted considerable attention to the manufacture of deck armor, with excellent results. I have the particulars of a trial where, in a plate of 5 ft. 3½ in., by 4 ft. 11 in. by 2¾ in., nine 100-lb. shots were fired from a 6-in gun at a square in the centre of the plate, the side of the square measuring only 15½ in. The velocity was of course low, being 535 ft. per second; but the peculiarity of the trial was that only one fine crack was formed between two of the points of impact. The same firm have also been experimenting with Harveyed armor, with the satisfactory results mentioned below.

German nickel steel plates.

Of the German manufacturers, Messrs. Krupp exhibited at Chicago several excellent plates, of which I select two for illustration here. The first is a nickel steel plate measuring 12 ft. by 8 ft. by 15¾ in. Four Krupp's steel and one chilled iron projectile, weighing 718 lb. each, were fired from a 12-in. gun, with a velocity of about 1,690 ft. per second. The chilled shot broke up and stuck in the plate, while the four steel projectiles were thrown back broken. The greatest penetration was 19.6 in., and the plate remained free from cracks. On 13th March, 1893, a 10½-in. nickel steel plate (hardened) was tested with excellent results. Five Krupp's steel projectiles were completely broken up without cracking the plate in any way. The particulars of the rounds are as follow:

	Round 1.	Round 2.	Round 3.	Round 4.	Round 5.
Gun..........	5.9 in.	5.9 in.	5.9 in.	8.26 in.	8.26 in.
Weight of shot	112 lb.	112 lb.	112 lb.	209 lb.	307 lb.
Velocity......	1,885 f.s.	2,000 f.s.	2,160 f.s.	1,727 f.s.	1,824 f.s.
Penetration...	2.7 in.	Not measurable.	12.2 in.	4.5 in.	Not measurable.

The trial is interesting, inasmuch as the behavior of the plates resembles closely that of the Harveyed plate, but it is evident that the shot was considerably overmatched.

The old-established firm of the Dillinger Huttenwerke Company has also given favorable examples of nickel steel armor, exhibiting the same absence of cracking which has characterized so many of the trials of this class of armor. I append the particulars of the tests of two plates which are worthy of notice.

Trial, 9th February, 1893: 8⅞ in. nickel steel.

Round.	Projectile.	Weight of projectile in lb.	Velocity in f.s.	Penetration in inches.
1	Steel, 6 in	112	1,554	10.5
2	"	112	1,543	10.8
3	Steel, 8¼ in	209	1,454	11.5
4	"	210	1,447	12.2
5	Chilled iron, 8¼ in......	209	1,442	9.6

Trial, 31st May, 1893: 15½ in. nickel steel.

md.	Projectiles.	Weight of projectile in lb.	Velocity in f.s.	Penetration in inches.
1	Steel, 12 in	714	1,700	22.2
2	"	715	1,677	21.9
3	"	714	1,664	21.5
4	"	714	1,665	22
5	"	714	1,701	12.5

ates are also being successfully manufactured in Russia, Italy, and in ne firm of Witkowitz in the latter country having been recently n the Pola trials. An account of these trials has so recently ap- I need not give any particulars.

Progress in manufacture of steel armor.

ove remarks show that, since the reading of M. Barba's paper Institution, a considerable impetus has been given to the manu- steel armor, and I have endeavored to give the results of the best f each manufacturer's plates in order to show what progress has It will be noticed that, with one or two exceptions, none of the ard enough to break up armor-piercing projectiles, which is the racteristic of the modern Harveyed armor yet to be noticed. As 1883 Admiral Acton, the Italian Minister of Marine, in explain- Chamber of Deputies the reasons for the preference of the Govern- mpound armor to steel, said that if the face of the steel could be hardened it might possibly be most successful in the future, and de Brown in the pages of the Engineer, has for some time advo- pplication to steel of the principle of hard faces and soft backs, as pound armor. As will be seen, this desideratum has now been ut before examining the results of the trials of the new Harveyed ust first treat of the experiments of compound armor plate manu- ubsequent to the trial of the standard plate of Messrs. Cammell, ibed. Although the question has apparently ceased to be of prac- st, a few instances of the improvements effected in increasing the the faces of compound armor may here be given.

over the Dutch trials of November, 1889, where a compound by my company broke up two forged steel Krupp projectiles, in f Captain Orde Browne, "like chilled iron," I come to later ex- Mr. Alexander Wilson has shown me a photograph of a 10½ in. plate, manufactured by his firm, which was tested in August, 1891, tely broke up three 6-in. A.P. projectiles, and two 6-in. Pallisers, velocity of from 1,956 ft. to 1,974 ft. per second. I am not able penetrations, but beyond two unimportant cracks the plate was uninjured.

THE TRESIDDER AND HARVEY PROCESSES.

The Tresidder treatment for hardening, and

t now mention some experiments made by my own company in the ion. The attention of my friend Captain Tresidder had been drawn rtance of endeavoring to break up the point of a steel projectile d time to effect any degree of penetration into the plate sufficient to cause perforation or serious damage by cracking. With this object in view, he tried various methods of rapidly chilling the face of armor plates; and, after obtaining fairly satisfactory results with cold air and steam impinging along the face, he directed his attention to the best way of hardening armor by means of a sudden uniform process of chilling by water. The process devised by Captain Tresidder was, and is, applicable and beneficial to all kinds of plates; but naturally, it has its most striking effect where carbon is present in sufficient quantity to ensure absolute hardness. My company being at the time large manufacturers of compound armor, Captain Tresidder's earliest experiments were conducted with that class of plate; and, although it subsequently became apparent that the hardening process* was more suitable to homogeneous than to built-up or compound plates commonly so called, the results of one or two of the trials are sufficiently interesting to deserve mention. The nature of the invention may be stated in a few words. It consists in the application of water under such pressure and of such volume as will effectually prevent any envelope of steam forming on the face of the plate, this ensuring a rapid chilling and resultant hardness uniformly over the surface of the plate.

results obtained from it.

The experiments were, so far as the chilling process was concerned, uniformly successful; but for my present purpose I only trouble the Institution with the consideration of one trial which took place at Shoeburyness on August 4, 1892. The dimensions of the plate were 8 ft. by 6 ft. by 10 in., and it was attacked by five 6-in. Holtzer projectiles, weighing 100 lb. each, with a velocity of 1,976 ft. per second. Captain Orde Browne describes the result of the trial as follows: 'The whole of the projectiles broke up with very little penetration. The plate, after the trial, appeared to be nearly as stiff and as strong as at first.'

Similar results were obtained in numerous other trials, the marked feature in each case being the complete breaking up of the best forged steel armor-piercing projectile in the same manner as the old compound plates had invariably broken up chilled Palliser shot. Of the value of the invention as a step in the development of armor there can be no doubt, but experience soon proved that its efficacy would be more strongly demonstrated by applying it to homogeneous steel plates, highly carbonized on the face, armor which has now generally become known as Harveyed armor.

The Harvey treatment

The late Mr. Harvey unfortunately died just at the time when the results of his plate had become known and acknowledged in Europe. Having successfully applied to smaller articles the system of cementation or conversion followed by chilling, he directed his attention to the effect of similar treatment in the case of homogeneous steel armor plates. A series of experiments was made under the auspices of the United States Government, and the results were from the first of a very encouraging description.

adopted by the British Admirality.

Inasmuch as this armor has been definitely adopted by the British Admiralty for the three important battleships now building, I have thought it would be interesting to the members of the Institution to give a detailed account of nearly all the trials that have been made of it in this country and abroad.

st includes the earliest American trials of the Bethlehem Iron and Carnegie, Phipps & Co., and the first Harveyed plate manu- Europe, that of Messrs. Vickers, tested in November, 1892.

no part of my purpose to draw comparisons between the plates of facturers. I desire rather to call attention to the results obtained ss of plate in the various trials taken as a whole, in order to dem- e extent of the improvement in armor realized by the new process. h tests appear to be most useful for this purpose, and, with the of the Director of Naval Construction, and the consent of the other anufacturers, I am able to give full particulars of all the British

BRITISH TRIALS OF HARD-FACED ARMOR.

king generally, the American trials are characterized by conditions re favorable to the plate than to the shot, while in France, with exceptions, the reverse has been the case. In England however, e of the trials made abroad, the authorities appear to have gauged ately the resisting power of the Harvey plate to the blow to be with the result that in many cases the shot and the plate appear to matched. A good instance is to be found in the trials of Messrs. and Messrs. Vickers' 6-in. steel plates on the Nettle. An exam- these trials will show that, with the highest velocity (1,960 ft. per 6-in Holtzer projectile was unable to perforate the plates, damaged d been by two previous rounds. According to the Gavre formula, would have perforated 11 in. of wrought iron (or 13 in., according rre's formula), so that we get a superiority to wrought iron of at per cent. Other instances may be found in the nickel steel 10½-in. essrs. Cammell, and in the nickel steel plate of the same thickness y own company, tested at Shoeburyness on 9th November and 10th 893, respectively. The Cammell plate was curved to moulds sup- he Admiralty, and was only penetrated to the depth of 10 in. In plate the projectile stuck in the plate, broken, and we may assume of the plates was a fair match for the blow delivered. The gun he 9.2, and, with a Holtzer shot of 380 lb. and a velocity of 2,035 ond (the highest obtainable), a striking energy was obtained of t tons. These conditions would give, according to the Gavre or De rmula, a perforation in wrought iron of 22 in. or 22½in., showing tes in question a superiority over wrought iron of 209.5 per cent., Again, the Chatillon Commentry 6.7-in. plate gives an excellent f a trial where the conditions of attack and defence approximate one

Matching shot and plate.

the severest blow, we find that the plate was not perforated by a h would, according to the Gavre formula, pierce a wrought-iron 1.9 in., and according to De Marre's, a plate of 13.8 in. in thickness; ords, showing a superiority over wrought iron of 177 per cent. ac- the one, and of 205 per cent. according to the other formula.

at first assumed that the Harvey process was considerably better nickel steel plates than to all steel, and this is still no doubt the general opinion in the United States. In the Annapolis trials of 1890 the Schneider nickel steel plate was undoubtedly superior to the all-steel plate made by the same firm; and in a trial of 3-in. plates in May, 1891, the nickel steel Harveyed plate was stated to be better than the all-steel plate. In the Indian Head trials of the same year, the low carbon all-steel Harveyed plate of the Bethlehem Company was placed considerably below the high carbon nickel steel Harveyed plate of the same company; but in this case the consideration of the question was complicated by the difference in the carbons, as it is probable that a nickel steel plate would not require to be so high in carbon as an all-steel plate to give the same resistance. Since this trial however it seems to have been assumed in the United States that all Harveyed plates should be made of nickel steel. In Great Britain however the high cost of nickel has caused manufacturers to turn their attention to producing Harveyed steel plates containing no nickel, and an examination of the details of the various trials shows that all have succeeded in proving the reverse of the theory accepted in the United States. There may perhaps be a slightly greater tendency to crack in the all-steel than in the nickel steel plates, as tested in this country, but this is more than compensated for in the superior resistance to penetration. The 6 in. Portsmouth trials all demonstrate this fact, and attention may also be called to the trial on 26th October, 1893, when experiment showed that the 10½-in. Brown all-steel plate more effectually broke up the 9-in. shot than was the case in the similar trial of the nickel steel plate under the same conditions. The expense of the addition of nickel renders this question of such importance that I regret there are no foreign trials available far providing further demonstration, if such be needed.

American tests of low and high carbon nickel steel plates not accepted in Great Britain.

The extra cost of nickel,

Apart from the question of extra cost, there are also practical considerations which affect the point in question. Some experiments made by Captain Tresidder show that a steel plate containing an ordinary percentage of nickel and a high percentage of carbon is practically unmachinable. If therefore a nickel steel plate be taken containing, say, 3 per cent. of nickel, and it be supercarburised up to, say, 1 per cent., its face will be so hard (even before the chilling process is effected), that for all practical purposes it will be impossible to drill and tap the various small holes that are nearly always necessary to be made on the face of the armor plates for ships' sides. In the case of steel armor, this difficulty (which I believe has already arisen in the United States in the case of nickel steel plates) does not exist, and thus one important objection to the adoption of the Harvey process for ship's plates as required by naval architects has been overcome by its application to all-steel armor in place of nickel steel.

and the quality of extreme hardness it imparts to steel.

I must now allude to the doubts that have been expressed as to the difficulties which will be experienced by manufacturers in adapting the process to curved and twisted plates. Both the Dutch and the Austrian Governments appear to have attached great importance to this consideration. No doubt there are, and will be, difficulties caused by the warping effect of the water treatment, and time alone will show whether they are as serious as the detractors of the system allege. I think however—and I am sure I can speak for the other armor plate manufacturers in this country—that any

Adapting the Harvey process to curved and twisted plates.

difficulties thus created will be readily overcome. In the first place, if a plate is uniformly heated, and uniformly chilled, any alteration of its form will also be uniform. A very little experience therefore will teach the operator the lines on which to work, particularly if the system of chilling in use is of a suitable character. We know also that the side armor for the Maine, made by the Bethlehem Company, has been accepted by the United States Government; and, although I have no accurate information on the point, we may safely assume that the plates were not straight. Both Messrs. Cammell and my own company have also successfully made sample Harveyed plates to moulds having both curve and twist, and probably other manufacturers have done the same.

Mechanical tests of soft parts of plate

It may be interesting to give an account of some mechanical tests showing the quality of the soft parts of Harveyed plates which have been successful in trials. In the early stages of our experiments a 4 ft. by 4 ft. by 9 in. plate was tested at Shoeburyness, breaking up the 6-inch Holtzer in the usual way without cracking. Test pieces were taken from the back of the plate with the following results:

——	First specimen.	Second specimen.
Breaking strain per square inch	31 tons	30 tons.
Elongation per cent. in 2 in	31	31
Reduction of area per cent	57	61
Cold bends without fracture	180°	180°

The plate, it may be mentioned, was not of our special armor plate quality. It gives however a sufficient indication that, apart from the face, the body of the steel does not, at least, suffer from the application of the process.

Resistance to shot by fragments of plate

One characteristic of this kind of plate must be specially mentioned . . I refer to the extraordinary resistance given to shot by small fragments of plate only. Perhaps the most conspicuous instance of this is given by the Bethlehem 14-in plate of 11th February, 1893, where a 10-inch Holtzer projectile was fired, at a velocity of 2,059 ft. per second at a piece of plate weighing only 4 1·5 tons, and was broken up with a penetration of 11 in. The total striking energy of the blow was 14,715 foot-tons, or 3,344 foot-tons per ton of plate. Another example may be found in a recent trial of a 6-in. steel plate made by my company. The fourth shot of this trial was fired nearly at the centre of the plate, after cracks had been made, such that the point of impact was about the middle of an equilateral triangle, with each side measuring about 2 ft. The 6-in. shot, with a velocity of 1,815 ft. per second, was completely broken-up; one small crack only was made, and the fragment of plate represented by the triangle, dished to the extent of an inch, showing the tough nature of the material. If therefore the Harvey plate be broken up, but its fragments still adhere to the backing, it still presents a considerable resisting power. It seems however from the foregoing remarks that it might be desirable to have a greater number of bolts per square foot of plate than was the case in the old form of armor.

EXTENT OF THE IMPROVEMENTS.

Estimate of the increased value in manufacture of armor-plate since 1888.

"With the above facts before us, we are enabled to form some idea of the improvements that have recently been effected in armor-plate manufacture, and of the relative value of the various kinds of armor. Without disregarding the excellent qualities of the steel and nickel plates which I have alluded to earlier in this paper, I think I have shown that Harveyed armor would be a more efficient defence to the vital parts of any ship of war, whether battleship or cruiser, than any other type of plate. Opinions may differ as to the percentage of superiority it possesses, but I do not think I am over-estimating its value when I place its resisting power at 50 per cent. above the steel and compound plates of 1888, which I have chosen as the basis of comparison. This advantage can be used by the naval architect in one of two ways: he can either clothe with armor a greater part of his ship, or he can obtain greater resistance, keeping the same thickness of armor. The new development is therefore of the greatest importance, and it will be a matter of satisfaction to this Institution that the British Admiralty have been the first naval authority in Europe to realize the value of this new form of armor, and to apply it to their most recent designs."[2]

IS GREAT BRITAIN TAKING THE LEAD?

Commenting on a paper read by Mr. William H. White, C.B., at the meeting of the Royal Institution of Naval Architects (March 15), London Engineer deals with the claim that "at the present moment England is taking the lead both in armor and ordnance," examines the ground on which the statement is based, and thinks it is possible that Mr. White may have referred to the continent rather than America.

Superiority of the Harvey system.

"The superiority of steel armor test plates treated on the Harvey system," it says, "to the untreated plates preceding them has been so abundantly established in this country that, in speaking of the question on its own merits, without any thought of continental armor, the only doubt is whether to credit the improvement as having amounted to 50 per cent. or some much higher figure." Having examined Mr. White's claim as to superiority over continental armor, the Engineer proceeds to say:

Severe tests adopted in the United States.

"The question on which most light was thrown incidentally by the facts which came out in discussion is the comparison of English Harveyed plates with those of the United States. Both in the use of nickel and in the Harvey process the United States were in the field before us. They tested their Harvey plates with 8-in. Holtzer steel shot; while we were attacking our compound plates, treated by the Tresidder process, with 6-in. shot only. Their plate trials have been in the very front as to progress. Last year they tested magnificent nickel steel plates with Carpenter projectiles made in America, which put to shame the Holtzer shot fired on the same day, although the latter were of smaller calibre, and therefore easier to manufacture. It needs then very clear evidence to establish a claim of superiority as compared

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[2] Charles E. Ellis at the Institution of Naval Architects, 15th March, 1894, published in Industries and Iron 8th June, 1894, pp. 669-71.

ited States, even for a moment. We think however that the
oints may be urged, although we speak doubtfully. Since the
of the Harvey process in England we have increased the severity
; in fact, discovering what could be learned by repeatedly testing
estruction; and investigation has led to the conclusion that
teel plates without any nickel in their composition are slightly
those containing nickel, their resisting power to penetration being
ough their toughness is less. In the United States nickel is used
, but it is doubted whether thick plates can with advantage be
the Harvey process. Without giving a distinct reason, the
n reluctant to subject their thick plates to the prolonged high
which is needed, urging generally how undesirable it is to do so
gain is very great; while they point out that the good effect of
ning and carbonization is necessarily limited to a depth which
less on thick than on thin plates. In addition to this we have
trouble is caused in America by the difficulty of drilling holes in
their hard plates. In the discussion which followed the reading
, Mr. Ellis stated two facts bearing on this: one that the presence
uses steel to crystalize at a much lower temperature than it would
nd the other that the 'arc light' system of drilling is not applicable
ontaining a high percentage of carbon and nickel together. It
a natural conjecture that the nickel in the United States plates
rouble both in the Harvey process and in the process of drilling,
le we have happily avoided owing to the decision to dispense with
this is so we shall find that the United States soon follow our
d we may in the meantime be said to have the lead that Mr.
ns; although we acknowledge that whatever may be the dislike to
Harvey process to thick armor, extraordinary results have in one
en achieved by a United States Harvey plate 14 in. thick. We
to admit that the remarkable series of successes achieved by
plates, conclusive as they are as to firing for experiment, have as
nvinced the continental powers that they ought to adopt them,
process causes the plates to bend and alter slightly in form, and
ot satisfied that this can be so calculated and allowed for or so
s to admit of armor being fitted properly to the form of the ship's
answer was given to this objection that the United States ship
been completed with her supply of Harveyed plates, that our own
e now succeeded in making plates to a given curve, and that no
culty is anticipated. We hope then altogether that at the present
stand in a very favorable position to furnish the new ships to be
with the best armor, and we trust soon to be able to give our
ailed evidence with regard to our guns."[3]

The qualities of resisting power and toughness in steel and nickel steel armor.

Objections to nickel steel.

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[3] From London Engineer, March 23, 1894.

CAPTAIN JAQUES' REPLY TO ENGINEER.

The letter of Captain Jaques which follows was written from New York under date of April 19, and in its issue of May 11 the Engineer made lengthy editorial comments upon it, but adopted the very singular course of withholding publication. At my request Captain Jaques has supplied a copy for publication in this Report of the Bureau.

"Sir,—In your issue of March 23rd an editorial, discussing the claim that Great Britain has taken the lead in armor and ordnance, advances (with hesitation, it is true) opinions that ought not to be passed by without at least friendly criticism.

The British critic and his qualifications.

My response is based on the assumption that the article in question was written by one who has for many years handled this subject for Engineer, viz., Capt. Orde Browne. He is a most persistent student of this special branch of war material; is one of Great Britain's first authorities on armor; has the confidence of his Government and of the contractors; and has access to much information and the results of trials which govern his opinions, but the details of which he cannot always give to the public. Further, he is perhaps the best fitted of anyone in England to make a comparison between the tests of the two countries, as he visited our Naval Proving Ground at Indian Head last summer with me and witnessed the tests of nickel steel armor of 9 and 17 inches thickness, and had the opportunity to examine carbonized plates that had already been given their ballistic trials.

I note he has expressed himself very cautiously; this caution appears to be personal admission that the evidence which decided the opinions of Mr. White and the First Lord of the Admiralty was not sufficient to convince him.

The opinion expressed by Mr. White at the meeting of the Naval Architects on the 15th of March, and to which Capt. Browne has referred, was not a surprise to me, as he had expressed the same views in a discussion of the subject during my last visit to England.

Mr. White has gone into the armor question during the past few years with the purpose of securing a protection for the splendid ships he has designed, at least equal to the best in the world; he has carried on experiments on a liberal scale; and he has given me the satisfaction of seeing *steel* armor replace *compound* in the designs of his ships.

While therefore I have great respect for Mr. White's opinions, I am not yet ready to admit that Sheffield has acquired the standard that we have reached; and although Great Britain has, in relinquishing compound armor, made great strides to the front, she does not yet lead the United States in the production of armor.

Mr. Charles Ellis' valuable paper on the development of carbonized armor is a most pertinent one for his pen.

As general manager of the Works where his father first attempted the carbonization of heavy armor, he knows all the difficulties that deferred the adoption of this process; and no one appreciates more than he the value of our work at Bethlehem in bringing the process to the stage at which the Harvey Company exploited it.

VALUE OF NICKEL IN CARBONIZED PLATES.

"The special points however that have suggested my reply to Capt. Browne's editorial of March 23rd are the statements which refer to England's claimed lead in armor, and the comparative value of nickel in carbonized plates. In connection with the latter it will be interesting to recall two official statements published about the same time. Coming from such high authorities they will necessarily be accepted by a majority of the people of their respective countries. But as their conclusions are so diametrically opposite, we must examine the information that has been given to the public to see which opinion is most soundly endorsed.

Official statements and opposite conclusions.

The First Lord of the British Admiralty (Spencer) under date of March 10th, 1894, said:

> 'In the course of the experiments the use of nickel as an alloy of steel for the purposes of armor plates has been fully tested. It has been established that Harveyed plates without nickel in the steel show resistance to modern projectiles as great as any hitherto obtained when nickel was combined with steel in plates, also treated by the Harvey process. The consequence of adopting this new system will be a great saving in cost for a given defence.'

First Lord of the British Admiralty, and

The Secretary of the United States Navy, in his annual report dated November 18th, 1893, covers the statement of his Chief of the Bureau of Ordnance that—

> 'Recent experiments at the proving ground demonstrate conclusively that nickel armor will afford more protection than is generally supposed owing to the fact that the line of fire under service conditions will be at an angle to the plate which is most advantageous to the plate, and also destructive to the projectile. Nickel steel plates offer great resistance at this angular fire because of the extra toughness of this material as compared with ordinary steel.'

Secretary of the United States Navy.

How is this marked difference in the conduct of carbonized plates of plain and nickel steel to be accounted for?

Evidence of the records of trials.

Individual American plates still have the best record, unless perhaps we exempt one of Krupp's, and that was *nickel* steel supercarbonized by a process of his own.

The best and thickest carbonized service plates have been made in the United States and are of *nickel* steel.

Although England occasionally tests a plate of service thickness, her general practice of reducing plates to a thickness of six inches for ballistic acceptance, while supplying a uniform specimen for test and comparison, does not give results that will always hold true in plates of greater thickness, or be a guide for the valuation of the service plates themselves.

Increasing the number of bolts to keep cracked plates in position brings us back to the old discussions of which is the least objectionable, considerable penetration without perforation, or cracks. Each nation, as heretofore, will probably decide it from the point of view of its own experiments, as Mr. White has done from the action of his six-inch Nettle plates.

The attempts to demonstrate the value of nickel in steel have been very unfortunate in England, and the question naturally arises, Why is nickel steel so expensive as to preclude its use in England?

The United States steel workers have had better success with nickel than even French makers, and the evidence which the Krupp, St. Chamond, and Bethlehem eight-inch to seventeen-inch plates furnish as to the value of nickel in carbonized steel armor should certainly carry more weight than the results of the six-inch plates tested on board the Nettle, on which Mr. White's recommendations appear to be based.

The English armor plate makers are reaping the benefit of American accomplishment in carbonization. Perhaps when they learn the American methods of incorporating nickel, the value of that metal in steel armor will be as enthusiastically admitted.

Relative value of carbonization in thick and thin plates.

Personally I have already expressed myself that the greater value of the carbonization was with the thinner plates; that—

'Although the recent development has been chiefly in the direction of securing a harder face to the homogeneous steel plates, there still remains two types for comparison: that of a resistance which will keep out a projectile of any calibre if thick enough, and that which will destroy the projectiles until a calibre is reached whose smashing and racking energy will demolish the protection, although perhaps at the risk of its own destruction.'

But the results of the experiments reported in the annual report of the Secretary of the United States Navy for 1893, viz —

'During the tests for acceptance of armor plates experiments have been made to determine the relative effects of impact of armor-piercing projectiles on ship's framing protected by ordinary nickel steel plates and by nickel steel Harveyized plates. In the experiments the backing representing the ship's framing was the same in each case. The untreated nickel steel plates receive nearly all the energy within themselves, and distribute it over the vessel in racking effect; while the hard surface of the nickel steel Harveyized plates causes the energy of impact to be principally absorbed in the disintegration of the projectile. The experiments developed a marked difference in the effects produced, in one case a much heavier nickel untreated plate being set back bodily several inches under impact of 100 foot-seconds less velocity than the lowest striking velocity with which the Harvey plate was attacked, while the latter was scarcely moved at all'—

reason for the carbonizing of plates of all thicknesses.

Usefulness of nickel established by United States tests.

It will be interesting to compare the future ballistic results obtained with service plates of the two nations manufactured in accordance with the recently expressed official opinions. Up to the present time the United States has carbonized more armor and a greater variety of shapes and thickness than all other nations combined, and her experience points to the usefulness of nickel in the methods she employs.

In Engineer's issue of July 16th, 1893, Capt. Browne said of the test he witnessed at the United States Naval Proving Ground, July 11th of the same year, that 'there is evidence here given that nickel armor has been probably perfected so as to resist fracture in a greater degree at Bethlehem than anywhere.'

This was spoken of uncarbonized nickel steel. The same can unquestionably be said of our carbonized nickel steel plates.

ite has admitted that the toughness given by nickel is of great
nbacked plates are used. When he tests the thick armor now
e Majestic and Magnificent he may find that a plate receiving a
2-inch or 13.2-inch rifle will behave so much like Gruson chilled
el or some other alloy will be needed to keep the plate together.
ng, disintegrating power of the larger calibres may make the
of an element like nickel not only valuable, but an absolute
ecure the toughness which becomes of inestimably greater value
lates.

Toughness a necessity to match the racking powers of large calibres.

, pointed out that the superiority of the nickel steel plate was
t more, due to the great experience in treatment and manipula-
percentage of nickel alloy. Perhaps the English nickel steel
tes are not as good as they can be made. The American who
ritish makers did not carry all of our experience with him.

facts mentioned by Mr. Ellis, 'that the presence of nickel
o crystallize at a much lower temperature than it would other-
hat the arc-light system of drilling is not applicable to plates
nigh percentage of carbon and nickel together,' have in no way
h our producing thick plates of carbonized nickel steel of a
e fine grain and fitted with as many holes and bevels on the
and edges as the most exacting sailor or cabinetmaker could

ne United States brought the present generally accepted type to
nich it is accepted by Sheffield; if we find no difficulty in carboniz-
seventeen inch thickness, if our carbonized *nickel* steel armor
r characteristics to carbonized *plain* steel, and if eight-inch and
ctiles, when attacking at velocities over 2,000 ft.-sec. make no
npression upon ten-inch and twelve-inch plates, Capt. Browne's
accept the statement of the Director of Naval Construction is
and he is wise in waiting the results of the comparative test of
than six-inch before he yields that nickel has no marked value
nt for the best armor.

Tests that suggest hesitation in accepting the British Admiralty's claim,

ur-ton fragment of fourteen-inch carbonized *plain* steel stands
n energy per ton of plate with less penetration and cracking
lehem's fourteen-inch carbonized *nickel* steel plate, or a record is
to that of Bethlehem's twelve-inch tapered ballistic test plate
he side armor of the U. S. S. Maine, Great Britain can
the lead in armor."

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eer of May 11 comments on Captain Jaques' letter (which it
tes was published by him), and concludes by saying:

Jaques' letter is very moderate and fair. He readily accords
he admirable Krupp plate exhibited at Chicago, yet we know
s been unfortunate since in one notable case. Altogether we
vill be time to claim superiority over Bethlehem plates when they
air competition."

and which Engineer is disposed to accept.

XI

DIAMOND DRILLS.

Introduction of the diamond drill for prospecting purposes.

Prospecting with the diamond drill was first tried in the coal fields of Pennsylvania in 1870, and this method of underground exploring has since been widely adopted to prove the extent of deposits of coal, iron and copper ores, gold, silver, etc. Where minerals occur in beds or large deposits, like coal and iron, the utility of this method of exploring is universally acknowledged. It has also been very serviceable in searching for gold, where it is found in blanket veins or in beds of auriferous alluvium, as in California and some parts of Australia; as well as in very large silver veins, like the Comstock lode in Nevada. But as regards the exploring of ordinary quartz veins carrying gold or silver, opinions differ.

To be used with caution.

T. A. Rickard, M.E., who spent some time in Australia, says the diamond drill is often likely to do irretrievable harm by fostering delusive hopes on one hand or by unnecessary discouragement on the other. The explanation is, that often in gold-bearing veins the ore is pockety, and that a drill-bore may pass through one or more pockets, showing the ore to be very rich, or may miss them altogether, showing it to be worthless. "If the drill is to be used at all," Mr. Rickard says, "the dangers attendant upon its use should be minimized by planning a series of holes close together, so as to test thoroughly and satisfactorily at least a small portion of ground."

Government drills in Victoria, Australia.

In the Colony of Victoria diamond drill prospecting for coal and gold is conducted under the control of the Department of Mines. In the report for 1891 Government Geologist Murray states that the total expenditure on boring since 1886 has been £30,000 for coal and £80,000 for gold. After summarizing the net results of boring for gold since the commencement of such operations, Mr. Murray says: "These results represent not only a very large amount of gold already won, but a still greater quantity the existence of which may be regarded as a certainty, and which will in due time be raised." The operations, it is considered, have been conducive to great economy of capital, as it has been practicable to select suitable sites for shafts in many places where otherwise it would have been necessary to trust to chance. "It may be fairly claimed," Mr. Murray asserts, "that not a single bore of the many hundreds put down has been utterly useless, with exception perhaps of some few that were sunk against the advice of the officers of the department, and the results even of these furnished useful experience for future guidance."

Cost of the work.

In 1891 the number of bores with diamond drills in Victoria was 102, and the aggregate depth 26,991$\frac{2}{3}$ feet, the total cost of which was for labor, material and transit (exclusive of diamonds) £9,747 7s. 2½d., or 7s. 2½d. per foot. Inclusive of cost of wear and tear of diamonds, the cost per foot was 11s. 5¼d.[1]

Grants to prospecting parties.

Another plan of Government aid in Victoria is by grants to companies or prospecting parties in opening up veins or deposits supposed to carry gold. The aid is made at a rate of 100 per cent. on the sum spent by the company or prospecting party, on condition that it shall be recouped if the mine is productive; but although £260,000 has been distributed in the six years 1886-91, the amount returned to the Government has been only £3,367. This fact, Mr. Murray says, speaks for itself as to the general non success of the system, justifying the assertion that the bulk of the money has been practically wasted. "The money has been distributed and expended with little practical and no scientific result; in fact, had it never been voted it is probable that mining enterprise would have gone on just the same, or perhaps even better, without the enervating influence that the scramble for participation in the prospecting vote has undoubtedly exercised."

Diamond drills in New South Wales, Australia,

In New South Wales diamond drills are under the control of and are fitted up and worked by persons employed by the Department of Mines. The drills are carried on railways free of charge, but cost of removing from station and setting them up upon the site selected for the bore, and returning to station, must be borne by the persons desiring to use them. Before use of a drill can be obtained the applicant must guarantee cost of removal as aforesaid, and fitting up at the site or mine, together with all charges for working the drill, including labor, loss of tubing, fuel, supply of water, repair of breakages, and £10 per week for wear and tear of machinery, destruction of diamonds, etc. The aim of the department is to work the drills in such a manner that the persons who employ them shall have their work done at cost price, and it is the duty of the superintendent to estimate the cost of each bore at such a rate as will just cover the amount. The total depth bored with six diamond drills in 1891 was 7,797¾ feet, the total cost of which was £5,825 14s. 6d., or 14s. 11¼d. per foot. The earnings of the drills are reported as £7,268 5s. 6d., or 18s. 8d. per foot, being a revenue above expenditure of £1,442 11s. But generally the accounts nearly balance. The diameter of bores is 3 to 4 inches[2]

in Queensland, Australia,

In Queensland two diamond drills were worked in 1891, but the results were not very satisfactory, owing in part to the broken nature of the rocks, but chiefly to the unpropitious character of the locations selected for boring.

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[1] In 1892 the number of bore holes put down for gold prospecting was 108. and the aggregate depth 27,272 feet; for coal prospecting, 20 bore holes and 17,574 feet. The aggregate cost of labor, material and transit for the former was £12,372 10s. 3d., and for the latter £8,339 12s. 1d., or at the rate of 9s. 0¾d. and 9s. 5¾d. per foot respectively. The cost for wear and tear of diamonds was 5s. 3½d. per foot prospecting for gold, and 2s. 11¼d. for coal.

[2] In 1893 three borings were made with diamond drills, and the total depth bored was only 1,903 feet 7 inches, the decrease being explained as "solely due to the great financial depression under which the Colony is now suffering, as the Government drills are only worked at the expense of those who use them." The borings however were of great depths, being continuations of previous work. One was of 3 inches diameter, from 749 feet to 1,010 feet 7 inches; a second was 5 inches diameter from 1,875 feet to 2,356 feet, and thence 4 inches to 2,929 feet; while the third, of unspecified diameter, was from 87 feet to 675 feet. The average cost for boring, exclusive of office salaries, store wages, rent and travelling expenses of superintendent of drills, together with clearing bores, reaming and repairing, was 12s. 4⅞d. The cost of wear and tear of diamonds, included in the above, was 3s. 3⅝d. per foot.

"There can be no doubt," the report of the department states "that the selection of sites in future must be a matter of the greatest consideration, the mechanical part becoming of very secondary import. The choice of the best site resolves itself simply into a geological problem, and it therefore should devolve only on persons that are thoroughly versed in the geological structure of the locality to be operated on."

and Cape Colony, South Africa.

In Cape Colony, South Africa, the Government imported two diamond drills in 1880, and in order to distribute as widely as possible the benefits of trial borings, Government lends the tools and services of the foreman to private individuals, charging only actual expense without any profit.

The desirableness of exploration with diamond drills in Ontario.

In Ontario there has hitherto been no deep mining by the sinking of shafts, with perhaps the two exceptions of the Silver Inlet mine in Lake Superior and the Copper Cliff mine at Sudbury. To prove that ore is continuous in depth is of very great importance, especially in the case of narrow veins; and no doubt this can be done most expeditiously and cheaply with the aid of a diamond drill. There is a risk however that the cores may not show a fair average of vein matter, and the drill should therefore be put in charge of one having experience and knowledge. It might be advisable to purchase two drills, one of which could be operated in the eastern part of the Province, including the gold veins of Hastings and the Lake Wahnapitae region, the iron deposits of Hastings, Peterborough, Frontenac and Lanark, and the nickel and copper deposits of the Sudbury district: while the other might be employed in the regions north and west of Lake Superior, including the iron ore deposits of the Mesabi range and the Mattawan and Atikokan rivers, and the gold veins of Lake of the Woods, Rainy Lake and Lake Manitou.

XII.

MINING ACCIDENTS.

wing table gives particulars of the mining accidents which have d to the Bureau during the year 1893 :

Accidents in 1893.

1	Jan. 9.	Dominion Mineral Co.	Blezard	Ennis Shrigley	Killed	Fell down shaft.
2	" 19.	H. H. Vivian & Co	Murray	D. McNaughton	Severely burned on back and hips.	Fell backwards into pot of molten slag.
3	July 13.	Canadian Copper Co	Copper Cliff	H. Kroskie I. Sala	Not seriously injured	Blasting hot ore at roast beds.
4	Aug. 17.	Canadian Copper Co	Copper Cliff	Albert Luckow	Not seriously injured	Blasting hot ore at roast beds.
5	Sep. 16.	Canadian Copper Co	Copper Cliff	H. Johnsen H. Cowcaw	Not seriously injured	Blasting hot ore at roast beds.
6	Oct. 16.	Canadian Copper Co	Evans	James Sheedy	Spine seriously injured	Caught by descending cage.
7	" 27.	Canadian Copper Co	Copper Cliff	Theophile Bouchard George Tremblay	Injuries resulting in death Slightly hurt	Premature explosion of dualin in hot roasted ore.
8	" 31.	Canadian Copper Co	Copper Cliff	William McDonald.	Right arm torn off	Caught in driving belt of ore crusher.
9	Nov. 9.	H. H. Vivian & Co.	Murray	A. Philipeck	Finger crushed	Loading car with ore.
10	" 9.	H. H. Vivian & Co.	Murray	D. Tzosiak	Eye cut	Splinter of rock knocked off by hammer.
11	" 10.	H. H. Vivian & Co.	Murray	John Owens	Shoulders burnt	Molten metal ejected by bessemerizing furnace.
12	Dec. 9.	H. H. Vivian & Co.	Murray	John McIntyre	Leg fractured	Fall of rock loosened by explosion.
13	" 21.	Canadian Copper Co	Copper Cliff	Alexander Bouchard	Injuries resulting in death.	Premature explosion of dualin in roast bed.

Killed, 3 ; injured, 13 ; total, 16.

General results of accidents.

The number of accidents which have occurred during the year is out of proportion to the scale upon which actual mining operations were carried on. Thirteen accidents have taken place involving sixteen men, of whom one was killed instantly and two died within a few days from their injuries. Of the remainder, three or four were painfully hurt and at least one permanently disabled. In the other cases the injuries were comparatively slight, and the men were detained from their work for short periods only. All the casualties reported took place, it will be observed, in the copper-nickel mines of the Sudbury district, where by far the larger part of the mining work of last year was done. The causes of the accidents were in the main those which are common to mining in general, and which indeed seem inseparable from the industry in whatever country carried on, such as premature explosions, falls of rock and ore, contact with molten metal, etc.; yet it is clear that there is room for the exercise of increased vigilance on the part of managers and foremen, and of greater care on the part of workmen themselves if bodily injury and loss of life in our mines are to be reduced to a minimum. Want of experience may have had something to do with the number of accidents. Mining in Ontario presents, in some of its processes and details, features of an unusual kind, and the dangers attendant upon these have, it would seem, not yet been fully appreciated or guarded against by mining companies and their managers. A case in point is the use of explosives in beds of roasted ore, which has been a leading cause of accident. It must be said too that many of the men employed in the mines of the Province are unused to the work, for a large proportion of them have been bred to other pursuits, and mining is a business where ignorance often pays a terrible premium to experience. Not that the old miner is always the most careful man, for in this as in other occupations familiarity breeds contempt, and risks are sometimes run in a spirit of foolhardiness or indifference, or to save time and trouble, from which men unaccustomed to danger would shrink. It is the place of experience to point out the sources of danger, and of wisdom to avoid them. As the necessity for watchfulness and caution becomes more and more apparent, it may be hoped that fewer casualties will occur.

Call for greater vigilance.

A leading cause.

PREMATURE DISCHARGE OF EXPLOSIVES.

Breaking up hot roasted ore is

It has been said that the premature discharge of explosives used in breaking up roasted ore was one of the principal causes of accident. Almost one-third of the whole number, and two deaths out of the three, were due to this cause. As all familiar with the working of the copper-nickel mines of Sudbury know, the ore after being crushed by the breakers is piled in large heaps containing hundreds of tons over a few layers of dry pine cordwood with a view to being "roasted," the object being to expel the sulphur which it carries in large proportion. The wood on being fired ignites the sulphur, and the ore-heaps smoulder away, emitting their sulphurous fumes for many weeks, according to the size of the pile of ore. At the end of perhaps three months the greater part of the sulphur has been driven off, and the ore is then ready to be taken to the smelter. But in the roasting process a partial smelting or fusion takes place, and the ore is no longer in lumps but in the form of larger or smaller masses which must be broken up before they are in condition for smelting. The use of explosives is generally necessary for this purpose, dualin being the agent chiefly employed. If the ore-heaps have been allowed to stand after burning until they become cool, there is no more danger in using explosives on the roast-beds than in the mine itself, although in any case it would be folly to entrust dualin to the hands of an inexperienced man. There is a temptation however when the smelters are in need of roasted ore to attack the piles while they are still hot, and it is evident that under such circumstances the use of explosives is attended with very much greater risk. To thrust a charge of dualin into a mass of ore almost at a red heat is to pay court to death, even if all the precautions are observed which are possible in such a case. This practice had obtained so great a hold, particularly in the roasting yards of the Canadian Copper Company, and had led to so many accidents, that it was deemed a proper subject of investigation by the Inspector of Mines.

Paying court to death.

THE CASE OF THEOPHILE BOUCHARD.

Previous to the explosion of the 27th of October, in which Theophile Bouchard received injuries resulting in his death on the 31st of the same month, several smaller accidents had occurred from this and other causes at the works of the Canadian Copper Company which, owing to ignorance of the law, were not reported to the Bureau at the time. On advice being received of Bouchard's death, and also of the previous accidents, the Inspector was instructed to make full enquiry into the causes and circumstances of these unfortunate occurrences with the object of recommending measures which might, if possible, avert such disasters in the future. The Inspector made a careful investigation on the spot and took the statements of all eye-witnesses and any who could throw light on the accidents or their cause. His report on the Bouchard fatality was as follows:

A special report by the Inspector of Mines.

COPPER CLIFF MINE, Nov. 9, 1893.

The following statements were made by the respective parties named in connection with the accident which occurred on the 27th of October last, when Theophile Bouchard was injured, which resulted in his death. The General Manager of the Canadian Copper Company furnished me with the following statement in writing:

DEAR SIR,—Mr. Trist has the contract for one year to handle and roast all ore coming from mines to roast beds. He employs and makes the rate of wage for his own men; the company having no control over them; nor have they ever had any in past contracts on roast beds. We have always ore enough on the beds to keep three furnaces of the present capacity on a continuous smelting. There is no necessity for working or blasting hot ore piles, as the daily supply of green ore from the mines to roast beds far exceeds the weight of roasted ore taken from the beds to be smelted, so that the tonnage of cold roasted ore should always be increasing, and not diminishing. At Mr. Trist's own request I have had to lessen the amount of green ore coming from mines, as he could not handle it quick enough. Yours respectfully,

The manager's statement.

JAS. MCARTHUR, Gen. Mgr.

The roasting contractor's statement.

Robert Wm. Trist, examined, says: I am contractor for roasting the ore for the Canadian Copper Co's. smelters. I have held this contract since the 1st of May last, and it is to continue from that date for one year. I receive the ore in its raw state on board the cars on the trestle track along side the roast beds. I take the ore from the cars, put it on the roast beds, see that it is properly roasted, and then deliver it at the smelters as it may be required to keep the smelters supplied. I am paid by the ton for this work. I furnish every thing to do the work, such as labor, tools, explosives and all else except the wood which is delivered at the roast beds by the company for use. I had been working previously for two years in roasting ore at the Blezard mine, and had full charge for nine months. The whole surface or field on which the roast heaps here are placed would hold at least 70,000 tons, and about 50 ordinary beds can be placed on it at one time. I work at several ore beds at one time, and when built up I fire them. I sub-let the removing of all the ore from the roast heaps and taking it to the smelters. I exercise a supervision over this sub-let work to see that it is done safely and that no unroasted ore is sent to the smelters. Each man is paid so much per car. The men loading the cars have each done their own blasting after having been instructed how to do it. It was customary formerly to remove the ore from the roast heaps after it had cooled off, but more recently it has been removed when hot. This was necessary to properly mix the ore, there not being on hand a full supply of different kinds of ore for smelting properly. I furnish the explosives to be used by the men in blasting the ore on the roast heaps. I have a foreman, Thomas Smiles, whose duty it is to assist me in looking after this work, and he is especially to look after the roast ore part of the work. I take the green ore part on myself, and a general supervision over the whole work. In removing the ore from the roast heaps it is first loosened up and then taken by wheelbarrow to the cars. When the ore is compact or tight, it is necessary to use explosives to loosen it. In blasting when the ore is hot it is the custom to open a hole in the roast heap at least four inches in diameter and then cool it by pouring in water. The charge is wrapped in wet clay and a sack put round it before being inserted in the hole. The instructions to the men are to put in the explosive charge thus prepared and then to go away and not stop to tamp it. A long fuse is attached to the charge and lighted before it is put in the hole. The charge is pushed in the hole with a stick and the men get away. Another way of blasting hot ore is by making a hole in the ore bed about six inches in diameter and fill it with wet clay; then after cooling it with water, if necessary, push a bar of iron into the clay to make a hole of sufficient size to admit the stick of explosive. The fuse is lighted and the charge is put into the hole to explode, the charge being first prepared by covering it with a coating of wet clay. The man Bouchard who met with the accident was one of my best men and had been engaged in using explosives in hot ore for some four months. He had been previously accustomed to the use of dualin, and although acquainted with this kind of work was not one of the most careful of men, for I had occasion to check him about two weeks before the accident. He was not regularly at work at the place where the accident happened, but went over from another roast heap to assist the man at this blast who had not much experience in blasting. This I learned from him after his injury. I had myself been engaged in blasting hot ore at the Blezard mine for from three to four months, and I do not regard it as specially dangerous if done properly. Six other persons besides the deceased have been injured of late by explosions, including the man who was injured with Bouchard, but all quickly recovered. The last injured man will be around in a few days. I have positively instructed the men always to go away on inserting the charge and not to stop to tamp the hole I was told by Bouchard that he remained a short time to tamp the hole when he should have left the place; but he remained and got hurt. I consider if my instructions had been carried out none of these accidents would have occurred. I never had any accidents occur in blasting at the Blezard mine in hot roast heaps.

The foreman's statement.

Thomas Smiles, examined, says: I am foreman of the roast yard and am employed by Mr. Trist. My work is to look after the men, and to see that cars are loaded at the roast beds and unloaded at the smelter. I look after the men while engaged in loosening up the ore on the heaps and wheeling it out; also to a certain extent over the blasting at the heaps. I always instruct new hands how to do the blasting, and go twice a day and deliver to the men the dualin or powder. I am employed by the day, but the men who load the cars are employed by contract, at one dollar per car. A car load averages about five and a half tons. The usual way of loosening up the ore on the heaps is by blasting. When the men are breaking loose the ore they require to put in about two blasts a day for each man. In instructing the men to blast hot ore I tell them to make a hole in the ore bed about four inches in diameter; then take the stick of dualin and roll it in a cloth spread over with wet clay until about four inches in size; then attach a fuse not less than two feet in length, and if the hole is very hot to light the fuse before putting in the charge. A two-foot fuse will enable a man to get half an acre away before the charge explodes. I also instruct the men to put wet clay in the bottom of the hole before inserting the charge. I have been engaged in this kind of work since 26th of May last. During this time there have been four mis-charges and seven men injured; one of them fatally, the others slightly. In following my instructions I consider there is no special danger. The custom was until the beginning of this month to have any of the men handling ore to do blasting, but since the last accident only two men have been allowed to do this work. The supply of ore for the smelters was so limited that we could not wait for the heaps to cool off. This is the reason why we removed the ore in its heated state. I was not present when Bouchard was hurt, but was informed that it was an act of carelessness on his own part.

Statements by employés.

George Tremblay, jr.

George Tremblay, jr., laborer, examined, says: I have been working for Mr. Trist since October 7th up to the date of the accident, October 27th. I was working on roast bed 200 at the time of the accident. Bouchard came to help me, as I had been at his roast heap 195 and helped him. I made the hole in the heap for the charge, and Bouchard prepared the charge and put it in the hole. I think he lit the charge before he put it in. I was making the hole while Bouchard prepared the charge, and did not see him do it. I put wet clay in the hole but did not put in water. After the charge was put in the hole I threw in a handful of dirt and was in the act of putting in dirt and Bouchard was tamping it when it went off. We sometimes tamped the charge when handy to do so, and at other times did not do it. We more frequently tamped the holes than otherwise. I was not instructed to either tamp the charges or not to tamp them. I learned how to do this by working with other men, and these men tamped the holes; do not know if Bouchard considered it dangerous or not. I have seen Bouchard tamp holes before. I often heard Bouchard say this was pretty risky work. I was never told how to do this by Mr. Trist or by Mr. Smiles.

George Tremblay, and

George Tremblay, examined, says: I am employed by Mr. Trist to work on the roast heaps at the Copper Cliff. I had finished my day's work when the accident occurred in which Bouchard was injured, on 27th October. I have been working for the past two months, taking the ore from the roast beds. I have put a few charges myself in hot ore, but usually I have had someone else put them in because I was afraid to do it. I was never told how to do this kind of blasting, except by the men who were with me. I have regarded the blasting in hot ore as dangerous. After Bouchard was hurt I went from my house and got him and brought him home. I never heard Bouchard say how the accident happened, nor did I ever ask him. Bouchard lived four days after the accident, and I attended him. He was my brother-in-law and lived with me at the time of the accident and death. I have worked with Bouchard on the same beds, and he has often put in charges for me. When the hole was very hot it was usual to go right away after the charge was put in, but when not too hot the holes were tamped. I have tamped holes.

Albert Luckow.

Albert Luckow, examined, says: I have been working for the Canadian Copper Company for about three years, and for the year past on the roast beds. I have had experience in blasting both cold and hot ores. I am hired by Mr. Trist, and I do my work by contract under him in removing ore from the roast heaps to the cars. The only way to break up the ore on the heaps is by blasting it. About two blasts per day are necessary for each man, and all or most of the men did their own blasting. It has been the custom to instruct the men how to do this work. I have been told how to do it both by Trist and Smiles, and also under the former contractor for whom I worked last summer. I do not regard blasting in hot ore as much more hazardous than in cold ore, provided due care is exercised. I blasted in cold ore only last summer. I only know of one accident last summer, and that was by Mr. Morrell, the contractor himself, in cold ore. A considerable quantity of hot ore was blasted last summer (1892), and every man did his own blasting. About two months ago I met with a slight accident by blasting in hot ore. This occurred by my failing to wrap the dualin up in wet clay on a rag, although I had put wet clay in the hole and pushed in a bar to make a hole for the charge—a common way of blasting. I was tamping the hole when the charge exploded. If the hole is tamped the charge will break up much more ore than by leaving it untamped. I do not know if any instructions were ever given forbidding men when blasting to tamp the holes, but they usually exercise their own judgment in doing this. I always tamp the holes. I do not know anything about the accident which occurred on 27th October, when Bouchard was injured. I heard of some other accidents by blasting in hot ore this summer, but do not know about them. I understand that two careful men of experience are now to do all this blasting in all the roast heaps, which I think is a good thing for safety.

The Inspector's conclusions.

The Inspector stated the conclusions he had arrived at in the following terms. "It is certain that Theophile Bouchard came to his death by an accident which occurred when blasting in hot ore. After inserting the charge he remained to tamp the hole where the accident happened, contrary to the instructions of Trist, the contractor; nor could Bouchard have been ignorant of the imminent danger of such a practice, as he had been engaged at this kind of work for four months. He had also been checked by his employer, but a couple of weeks before, for carelessness. I consider that at the time of the accident he did not exercise such due precaution in blasting as he might have done to avert it. From the information obtained, I am satisfied that the practice of tamping holes after charges were put in had become too common among the men. I have carefully examined the whole system of blasting in hot ore, and I regard it as a practice attended with too great danger to be allowed. A recent change has been made on the roast yard at the Copper

Cliff, viz., in not permitting every man working on the roast beds to do his own blasting, as the custom has formerly been, but by limiting it now to two careful men of experience. This no doubt will greatly lessen the risk of accidents, but will not entirely remove it."

Coroner's inquest on the case.

A coroner's inquest was held on the death of Bouchard by Dr. R. B. Struthers of Sudbury on 1st November. The jury returned the following verdict:

> That Theophile Bouchard came to his death as the result of an accident brought about by his own carelessness. And we strongly recommend that such means as are necessary be taken to get and keep on hand a sufficient stock of ore so that men will not have to work and handle hot ore. In the meantime we recommend that one man only, and he an experienced one, be allowed to fire on holes in hot roast beds.

THE CASE OF ALEXANDER BOUCHARD.

Another fatal occurrence from the same cause.

The fatal accident to Theophile Bouchard was followed on 21st December by another from the same cause, by which Alexander Bouchard was mortally wounded, though he did not actually die until 3rd January, 1894. The circumstances attending the second fatality were pretty much the same as those of the first, with the exception that the ore in which the deceased was working is described as being "not very hot." Previous to the time of the first accident it appears to have been the custom to allow men working on the heaps of roasted ore to handle their own explosives. At the Canadian Copper Company's works the breaking up and delivery of the roasted ore is carried on by a contractor, who employs and directs the workmen, the company disclaiming any responsibility in connection with this department of the work. On the 3rd of November, moved thereto by the recommendation of the jury at the inquest held on the body of Theophile Bouchard, the contractor (Mr. R. W. Trist), entrusted the duty of using explosives on the ore heaps solely to one man experienced in this branch of the work, and at the same time forbade the workmen to use the explosives themselves. The men however were paid by the piece, and being anxious to get on with their work, whenever they found it inconvenient to wait for the services of the man appointed to do the blasting, they did not hesitate to make use of the powder themselves if they could get it. The man, Paul Rioux, placed in charge of the exploding, seems to have had somewhat lax ideas about the way in which his instructions were to be carried out, for on several occasions he gave powder to the men for their own use. On the day of the accident Rioux was laid off work with a frozen foot. This was known to Thomas Smiles, the foreman at the roast yards, whose duty it was in the blaster's absence to attend to this dangerous work himself. He made no effort to do this, or to have anyone put in Rioux's place; but instead authorized the men to get the key of the powder-house and help themselves. This the men, unwilling to be idle, were in no way reluctant to do, and they procured the necessary dualin to loosen the ore and proceeded to make use of it. Napoleon Sauve, Bouchard's neighbor on the ore heap, testified that after deceased had made a hole in the ore in which to place the cartridge, he pushed the latter home with a broom

An instruction disregarded,

and the fatal consequence.

handle, when the charge at once exploded. Bouchard received terribly severe injuries, chiefly about the face and shoulders, the ball of one eye being completely destroyed, and the other nearly so. Blood poisoning set in at the end of a week, and death took place on the 3rd of January.

A thorough investigation ordered.

Owing to this second fatality following so closely upon the first, it was determined to make it the subject of a thorough investigation, and accordingly instructions were given to stipendiary magistrate Doran of North Bay to conduct a coroner's inquest on the body. Mr. J. H. Metcalf, Pembroke, Crown Attorney for the county of Renfrew, was detailed to assist in prosecuting the inquiry. A jury of twenty-two residents of Sudbury was impanelled, with Stephen Fournier as foreman, and the circumstances of the accident as given briefly above were fully brought out. The verdict of the jury was as follows:

The verdict.

That Alexander Bouchard did come to his death accidentally from his own careless handling of explosives. We also wish to strongly recommend that mining companies should not be released from the responsibility for the safety of their men, but should supervise their works in all its departments where men are exposed to danger, and not allow such lack of care as was shown by the contractor and his foreman on the roast beds at Copper Cliff, which may possibly have led to the death of deceased Alexander Bouchard.

Laxity of supervision.

The jury, while satisfied that primarily Bouchard was responsible for his own death, evidently felt that there was a laxity in the supervision and management of this department of the company's operations which was inconsistent with a proper regard for the security of the men employed in it. Where blasting operations are carried on above ground, and in the light of day, it ought not to be difficult to surround the use of explosives with safeguards which will almost entirely do away with the possibility of such disasters. If a mining company can rid itself of responsibility for the safety of workmen by letting out to a contractor the work on which they are employed, such responsibility does not cease to exist, but devolves upon the contractor; and it is therefore the bounden duty of the latter to take every possible precaution, even if need be against the inclination of the men themselves, to prevent injury and loss of life. In this case the coroner's jury were of opinion that the contractor had not taken such precautions, and that his foreman, Smiles, showed great carelessness in the matter. The latter was indeed reprehensibly negligent, for although, to use his own words, he was fully aware that in the absence of Rioux he "was responsible for the powder and blasting," and that "none of these men should have been allowed to get powder from the powder-house that day," he nevertheless, according to the testimony of the workmen, expressly instructed them to get the powder for themselves and do their own blasting. While such gross and indeed almost criminal carelessness is permitted by mining companies and mining managers in the handling of dangerous explosives, we can expect nothing but a repetition of fatalities of this kind. Mining is at best a more or less hazardous occupation, and there are causes of accident which the exercise of the utmost caution and vigilance can hardly eliminate; but where a few simple rules rigidly enforced would almost wholly remove danger, as in this case, it is a pity that such safeguards are not adopted.

REMEDIAL MEASURES PROVIDED.

Notice to discontinue practice of blasting hot ore.

The Inspector's investigation of the Theophile Bouchard fatality having shown that the practice of blasting in hot ore was a dangerous one and ought to be discontinued, formal notice was served by him upon the general manager of the Canadian Copper Company and the contractor for roasting that company's ore, in the following terms:

> Sir,—An investigation into the causes and circumstances of recent accidents at the mines and works of the Canadian Copper Company at Copper Cliff having convinced me that the blasting of hot ore on roast heaps is carried on at the risk of life or bodily injury to the persons employed thereat, I hereby notify you and any contractors or others employed upon or about the mines and works of said company under your authority, by virtue of the power conferred upon me by the sixty-fifth section of The Mines Act 1892, that such blasting of hot ores is a dangerous practice within the meaning of the Act, and to require that it be discontinued forthwith upon receipt by you of this letter.

Provision against the practice by legislation.

Similar notice was given to the managers of H. H. Vivian and Company and the Dominion Mineral Company. The prohibition of blasting in hot ore was made permanent by a clause in the Act relating to Mines and Mining Lands passed by the Legislature in the session of 1894. Section 10 of this Act amends The Mines Act 1892 by adding to Rule 2, section 74 thereof, the following clause: "No gunpowder, dualin, dynamite or other explosive shall be used to blast or break up ore in roast heaps where by reason of the heated condition of such ore or otherwise there is any danger or risk of premature explosion of the charge." The said section was further amended by inserting in Rule 21 after the word "mine" in the sixth line thereof the words "or contractor or foreman employed in or about such mine." The effect of the latter amendment is to make a contractor or foreman liable in case of an offence against the Mines Act as well as an owner or agent, unless he can prove that he has taken all reasonable means to enforce the Rules provided by the Act and to prevent non compliance therewith.

OTHER CAUSES OF ACCIDENTS.

The Inspector's inquiry and report on the case of Theophile Bouchard also covered the accidents to James Sheedy and William McDonald, numbered 6 and 8 respectively in the table given above, both of which, though not fatal, were of a serious character.

Accident in a shaft.

On the 16th of October Sheedy, who was employed in the underground workings of the Copper Cliff mine, wishing to descend from the third to the fifth level, leaned forward into the shaft for the purpose of pulling up a gate in order to clear the way for the cage. While in the act of doing this, the cage descended and doubled him up, inflicting injuries upon his spine. He was sent to the General Hospital at Toronto for treatment, where he recovered, the company paying all his expenses. It was clearly shown, and indeed admitted by the injured man himself, that the accident was entirely due to his own want of care. A hook was provided for the purpose of raising the gate in question, but it was a few feet away from its usual position at the time, and rather than look for it Sheedy leaned forward and attempted to raise the gate by hand. The engineer was positive he received the usual signal of two bells to lower the cage, but it could not be ascertained who gave it.

Machinery Accident.

On the 31st of October William McDonald, 17 years old, had his right arm torn off in attempting to throw off the belt of the ore-crusher screen in the Copper Cliff rock house while the machine was in motion. This painful accident was due to his own lack of prudence.

Killed by falling down a shaft at the Dominion Mineral Co.'s mine.

Ennis Shrigley lost his life at 5.30 a.m. on the 9th of January, by falling down No. 4 shaft of the Dominion Mineral Company's mine at Blezard. The circumstances of the accident were as follows: This man, who was about 45 years of age, was employed at the head house emptying buckets which were being hoisted up through the shaft, the dimensions of which were 3 feet 6 inches long by 2 feet 5½ inches wide. With two others he was warming himself at a fire about three feet from the shaft opening. He stepped away from the fire to get some wood, and the others hearing a slight noise turned and saw him fall down the shaft head first. The opening is fenced at the front and back, but not at the sides, where the aperture is only large enough to admit of a car being run forward to receive the contents of the buckets. The man was instantly killed. It is supposed that he was either dazed by the cold, the weather being very severe, or was taken in a fit. An electric light was burning within two feet of the hole at the time. The coroner was advised, but declined to hold an inquest unless requested to do so by the company or some relative of the deceased. As such request was not made, no inquest was held.

Accidents of a minor character.

The other accidents were of a minor character, the most serious being those to D. McNaughton and John McIntyre, both of whom were injured at the Murray mine owned by H. H. Vivian and Company. The latter had his leg broken by a fall of rock. The former while walking backwards and wheeling a pot of molten slag and metal had the misfortune to sit down in a similar pot of slag and metal carelessly left in the way by a fellow workman. He was painfully burned, but not permanently injured.

CORONERS' INQUESTS.

Independence of officers holding inquests.

In connection with the investigation of mining accidents, it was felt that there were grave objections to the practice of allowing coroners to conduct inquests in the case of persons who had been in the employ of companies or firms by whom the coroner was himself either directly or indirectly employed as medical adviser or interested as a stockholder. It is a common arrangement with mining and other companies to engage a physician at a stated figure per man to attend upon their employés, such sum being usually deducted from the men's wages. It is obvious that when a fatal accident occurs in the operations of such a company a coroner who is also the company's physician is not in a position to conduct an impartial investigation. It is no reflection upon the integrity of gentlemen so situated to say that their independence would be open to serious question, and that the friends of a man who met his death by accident would be inclined to view the actions and regard the motives of such a coroner with greater suspicion than in the case of one not connected by ties of interest with either side. The preliminary investigation conducted under the direction of a coroner is usually of a grave and important character, and it ought not to be open to attack on the ground of the real or alleged partiality of the coroner. Having these considerations in view, representations on the subject were made by the Bureau to the Attorney-General's Department, and in the session of 1894 provision was made in the Act respecting certain Duties of Coroners (57 Vict. chap. 31, section 4) by which a coroner under the circumstances described above is declared incompetent to act. The clause enacted is as follows :

Statutory provision of incompetency in certain cases.

> It shall not be lawful for a coroner to conduct an inquest in any case where loss of life has been caused at or on railroads, mines or other works whereof he is owner or part owner, either as shareholder or otherwise, nor in any like case at or on works where he may be employed as medical attendant by the owner or owners thereof, or by any agreement or understanding direct or indirect with the employés at or on such works.

T. W. G.

XIII.

KINGSTON SCHOOL OF MINING.

The Kingston School of Mining and Agriculture has been organized under an Act of the Legislature of Ontario. Its objects as stated in the calendar for 1893 4 are as follows:

Objects of the School.

1. To give a complete scientific education of both a theoretical and practical character to young men studying for metallurgists or mining engineers.
2. To give practical instruction to prospectors, mine foremen and others interested in the discovery and winning of minerals.
3. To lead prospecting excursions of the students as well as of those more directly interested in the development of mineral lands.
4. And to provide theoretical and practical instruction in subjects pertaining to modern agriculture, such as dairying, veterinary science and the chemistry, botany and zoology of the farm.

Its organization.

The School has been founded on a joint stock basis, being authorized to issue stock to the amount of $100,000; but in addition it receives a grant of $5,000 yearly from the Province of Ontario, and may also receive aid from local or county municipalities. The management is in the hands of a Board of Governors, composed of the following gentlemen:

J. B Carruthers, Esq., Chairman	Kingston.
Hiram A. Calvin, Esq , M. P., Vice-Chairman	Kingston.
G. M. Grant, LL.D.,D.D.	Kingston.
E. W. Rathbun, Esq	Deseronto.
James Swift, Esq	Kingston.
G. M. Macdonnell, Esq., B.A.,Q.C	Kingston.
E. J. B. Pense, Esq	Kingston.
William Harty, Esq., M.PP.	Kingston.
James S. Haydon, Esq	Centreville.
M. H. Folger, Esq	Kingston.
J. L. Whiting, Esq	Kingston.
George Y. Chown, Esq	Kingston.

The mining department opened.

Its scheme.

The Mining Department was opened on the 9th of October last year, but arrangements have not yet been fully completed for opening the Agricultural Department. The scheme of the School in relation to the mining courses will be readily understood from the following provisions, adopted by the Board of Governors previous to and during the first session:

I. The degree of Mining Engineer (M. E.) will be conferred on those who take the specified course and pass the required examination.

II. Unmatriculated students may take any classes and examinations that they wish, as it is desired to give opportunities to persons who do not intend to follow engineering as a profession to receive the benefit of courses likely to be useful in common life.

III. Special courses of instruction to mine foremen, assayers, prospectors and mining men generally, continuing for eight weeks.

IV. Evening lectures for persons desirous of learning something of the course, but unable to attend during the day.

V. Short courses, accompanied with experiments, specimens, diagrams, etc., by one of the staff in outside localities.

VI. A summer School of Science for Public and High School teachers and others, continuing in session for five weeks.

Classes of the first session.

The following memorandum of classes in the Mining Department of the School for the session of 1893-4 has been furnished me through the kindness of Rev. Principal Grant of Queen's University, a member of the Board of Governors :

I. *Number of Students :*

		Fees paid.
(*a*) Number of regular students	102	$1,506 34
(*b*) Number taking short courses	47	176 00
Total		1,682 34

II. *Classes taken by the Regular Students :*

	Professor or Lecturer.	Number in Class.
Junior Chemistry	Dr. Goodwin	48
Senior Chemistry		43
Analytical Chemistry (Elementary)	Dr. Wood	29
Junior Practical Chemistry		39
Organic Chemistry		33
Quantitative Analysis	Mr. Walker	4
Qualitative Analysis		9
General Practical Chemistry		2
Honors, Chemistry of Fuel, Ores, Fluxes, etc.	Dr. Goodwin	12
" Organic Chemistry		8
" Crystallography		9
" Physiological and Pathological Chem.		3
" Quantitative Analysis		3
Mineralogy, 1st year	Mr. Nicol	14
Blowpipe Analysis		15
Honors, Mineralogy, 2nd year		4
" Mineralogy, 3rd year, Descriptive Mineralogy		2
" Mineralogy, Determinative Mineralogy		1
" " Blowpipe Analysis		1
" Qualitative Analysis		5
" Assaying		4
Geology, 1st year pass ; Field work, Museum work and General Geology	Mr. Miller	12
1st Honor, Petrography, Physical Geography, Palaeontology, Dynamic Geology, etc., Laboratory work, Museum work and Field work		9
2nd Honor, Advanced Geology — Historical, etc., Economic Geology—Ore deposits, etc., Petrography, Geology of Canada, Museum work, Laboratory work	Mr. Miller	5
Drawing	Mr. Mason	6

III. *Classes taken by the Short Course Men :*

Any of the above classes for which the men were fitted ; in addition, special instructions by the above-mentioned members of the staff ; also, courses of lectures, illustrated by diagrams, specimens and experiments, by W. Hamilton Merritt, M. E., on the application of the principles of chemistry, mechanics, mineralogy and geology to the discovery and winning of valuable minerals, and to the usual methods and machinery in vogue to open up the deposits and exploit and prepare the ore.

Courses for students.

It will be observed that the students are comprised in three distinct classes, viz.: (1) Mining students proper, who take the four years course; (2) students who take the eight weeks course; and (3) special students.

Six students are taking the full course of Mining Engineering, having entered upon it at the opening of the session in October.

The eight weeks course did not open until the 9th of January, when a class of seven men was formed, who took lectures in chemistry, mineralogy and blowpiping, geology and petrography, assaying, drawing, prospecting and mining. Class-room attendance occupied 300 hours in the 48 days of the course, or an average of 6¼ hours per day. The work was largely of a practical character, and the students entered into it very heartily. I had the honor of visiting the school towards the close of the first term, at the invitation of Principal Grant, and two days were spent in the several class-rooms. I cannot speak too highly of the spirit which prevailed in the school on the part alike of professors and students; and I have no doubt that this departure, which is a novel one in the educational institutions of Ontario, will in time be productive of very beneficial results on our mining industry.

The evening class had a registered attendance of 23, to whom lectures were given during the course, illustrated by experiments, diagrams and specimens.

Equipment of the School.

The equipment of the School is modest as yet. Besides accommodation for 24 blowpipe students, there are three wind furnaces, one large muffle furnace, one charcoal furnace, one portable coke furnace and three gas furnaces, the object being to teach assaying with all kinds of fuel.

For the present the School is housed in the John Carruthers Science Hall—one of the solid buildings of Queen's University—but it is probable that ere long it will have a hall of its own, with a complete outfit for a well established School of Mines.

Outside classes.

At the close of the short course in March of this year Mr. W. H. Merritt, one of the lecturers, conducted a special class at the village of Marmora. It was on the plan of the New Zealand schools, and the course extended over a period of two weeks. Seventeen students attended the lectures there.

REPORT OF THE INSPECTOR OF MINES.

To the Director of the Bureau of Mines:

Sir,—I have the honor to transmit to you my fourth annual report on the Inspection of Mines, being for the year 1893.

Inactivity owing to the financial depression.

The brevity of the report is in part due to the fact that a very considerable number of the mines have been lying idle during the year, notably those of iron, silver and phosphates. A large number of these mines have been worked extensively in former years, and, hoping along the line of our interests, we may anticipate a renewal of operations at not a distant date.

A number of causes have recently arisen which have combined to prevent an extensive development of our mines. Although Canada has been exempted in some degree from the heavy financial depression resting upon other countries, yet serious effects have been realized in this Province by reason of the capital which would otherwise have been expended in mining interests having been withheld, and especially is this the case when largely dependent upon the neighboring Republic for the capital required to push forward the work in the mines. The general suspension of business in many quarters in that country, and the repeal of the Sherman Act (which in effect shut down the silver mines in all the silver-bearing States), could not fail to have a depressing influence upon our mines. With the revival of silver mining in Colorado and other important producing centres, we may reasonably anticipate that the hitherto large yielding properties in the Thunder Bay district will again be vigorously worked, and that many of the encouraging discoveries of silver and other mineral deposits now lying undeveloped will be opened up.

Since the entire suspension of silver mining, much more attention has been given to gold mining in Ontario, which has an encouraging outlook.

I have made no report upon the gold and copper mines of the Province, as you have had the opportunity of personally examining them, and will no doubt give a full description of their present condition.

SILVER.

Rabbit Mountain mine.

A special correspondent of the New York Engineering and Mining Journal in October says of Rabbit Mountain mine: "This mine, under option to a Duluth company, has been closed after shipping a car load of picked ore, the result of the season's work. It was the last of the Thunder Bay mines to remain in operation."

New discoveries west of Port Arthur.

Mr. Hille, M.E., of Port Arthur, states: "Last year a number of gold veins were discovered not more than 50 miles west of Port Arthur which promise well. The veins vary in width from 2½ feet up to over 40 feet, and the ore assays from $10 to $50 in gold and silver. The ore is not free milling, but is through the occurrence of a large percentage of copper a very good material for Dr. Hoepgaer's process."

Ogema mine.

The Ogema mine was sold at public sale at Port Arthur, August 15th. The affairs of the company will be wound up on account of dissension among the stockholders. The mine, which has not been worked for some time, was bought by J. F. Ruttan of Port Arthur for $925.

COPPER AND NICKEL.

Canadian Copper Company.

Work was being actively carried on in Copper Cliff mine at the date of my visit in June, under the charge of the late Captain James. Twenty men were employed on the day and night shifts, and about seventy-five tons of ore lifted daily. The principal workings were in the fifth, sixth and seventh levels, for a description of which see former report. Especially in the seventh, the lowest level in the mine, an excellent body of ore was exposed, and appearances would indicate its continuance to a much greater depth. The workings at this point, nearly 500 feet vertical depth from the surface, are the lowest reached in any of the mines in the locality. The excellent showings at the depth named should strengthen the conviction of the existence of large bodies of nickel ore at great depths, which if demonstrated must necessarily enhance the value of nickel properties throughout the Sudbury district.

Copper Cliff mine.

Progress of mining operations.

In view of the existence of this large body of ore and its probable continuance to much greater depth, as well as the long distance of the drifts to be run in from the incline hoist track, it has been determined by the management of the company to sink a vertical shaft directly upon the ore.

The work in the mine was being conducted with the usual care and safety. I directed the attention of the captain to the large original opening at the surface which required fencing, and he had this done at once.

In November this mine was under the care of Captain Davis, who had but recently assumed control. He accompanied me through all the parts of the mine then being worked. The usual force of men was employed both underground and above ground. The showing of fine bodies of ore in the mine was not less encouraging than at the time of my former visit, especially in the deepest workings. A large quantity of ore was being taken out and prepared in the usual way for the roast yard in the rock house, which is a convenient and substantial structure. The work, both in the mine and in preparing the ore for roasting, was being managed with apparent economy, and due care was paid to the safety of the workmen. The air receiver at the compressor, which was dangerously exposed at my former visit and to which I called the attention of the master mechanic, had been neatly and substantially protected by a sheath..

Mr. James McArthur, who formerly had charge of the smelting department, has now the general management for the company. In a recent communication he states: "As usual the cold weather in December compelled the stoppage of ore raising, and none has been produced since the middle of that month. Outside of this there is nothing new to report."

Accident.

An accident occurred in the rock house in this mine on the 31st of October, when William McDonald, a young man, had his right arm torn off near the shoulder by a belt. He was imprudently pulling it off the pulleys when part of the machinery was in rapid motion. The particulars of this accident are given in a special report on accidents to the Honorable Commissioner of Crown Lands.

The smelting furnaces.

The smelters had been standing idle for some time, but started up in May, and in the latter part of June about seventy-five men were employed. They were running to their usual capacity and doing efficient work. One of the engines required railing put up to prevent accidents when passing it, which was done. In November they were also thoroughly manned, in excellent running condition and doing their full quota of work, averaging about 200 tons of ore daily. A large stock of wood was on hand. Nothing new to report by addition or change to the plant except the following, as stated in a recent note from the manager: "An enclosed overhead passage-way is running from No. 1 furnace to the outer slag dump. Our granulated slag is conveyed through this passage, which was built by the company for the comfort of the men as a protection against the weather."

The roasting yard.

The ores from the three mines of the Canadian Copper Company, the Stobie, Evans and Copper Cliff, are taken to the large roast yard near the smelters for calcining. The yard is of sufficient size to hold eighty or ninety thousand tons of ore, and from fifty to sixty roast heaps containing fifteen or eighteen hundred tons each may be built upon it. These huge piles of ore require ten weeks or longer to burn, and a considerable period of time to cool off. The ore is roasted by contract, and the general manager disclaims control over this part of the work.

Accidents due to the practice of blasting hot ore.

During the season a departure from the usual custom of allowing the roast heaps to cool off before being removed had been adopted by the contractor, by breaking them up in their heated state with the use of explosives. This practice resulted in a series of accidents caused by unexpected or premature explosions, two of which proved fatal.

In pursuance of instructions, I made a careful examination as to the causes of these accidents, except the last, and submitted a special report thereon to the Honorable Commissioner of Crown Lands.

I regarded the practice of blasting in hot ore as dangerous and likely to cause personal injury and loss of life, within the meaning of the Mines Act, and accordingly gave notice to discontinue it.

Although believing that this practice was not followed at other roast yards, yet as a precaution against and for the purpose of preventing it, I issued similar notices to the managers of all companies at whose works ores were being roasted, which precaution I am informed met with their entire approval.

In November about fifty-six thousand tons of ore were on the roast beds, and from sixteen to eighteen thousand tons of green ore were on hand.

This pioneer company has produced up to December 1st 300,000 tons of ore and 40,500 tons of matte—equivalent to about 6,500 tons of copper and 5,600 tons of nickel.

Stobie mine.

Late in June but little work was being done in the Stobie mine. The walls were being trimmed and some parts of the interior fitted up under Captain John M. Jones, who had formerly been in charge of Copper Cliff mine. The large open pit was partially filled with water, but could be quickly emptied when necessary to resume lifting ore.

The new rock house and machinery.

The new rock house had been completed. It is a substantial structure, 40 by 50 feet and 70 feet in height, and superior to any other in the Province. It is supplied with a powerful Blake crusher capable of breaking 125 tons of rock in ten hours, and has space provided on the floor for placing three others of equal capacity when required. The dump floor was to be covered with three-quarters inch steel plate, which was on hand and ready to be put in place. The whole is admirably fitted up with screens, chutes, etc., and a track underneath where the cars may receive the ore from the bins when sorted, crushed and screened, to convey it to the roast yard at Copper Cliff. In the building is placed a 30 h. p. engine to drive the crusher, screens, etc., the steam being supplied from the boilers placed in the adjoining engine house. This building, situated fifty feet east of the rock house, is also a fine structure in which are placed two boilers, each of 80 h. p. capacity, and a powerful engine to drive the large Ingersoll air compressor, capable of running seven three-inch drills. There are also two drums for hoisting ore, with engines attached of 40 h. p. each, capable of lifting with skip not less than four tons at each hoist. There is a large heater for heating the water before going into the boilers, and also an air receiver of large capacity.

A good incline skip track was being constructed from the dumping floor of the rock house to the open pit. From the drums in the engine house the strong steel cables pass over pulleys and reach the upper apartment of the rock house and connect with the skips, having a capacity of two tons each.

The machinery had not yet been started, but was put up in a thoroughly workmanlike manner and of the most approved class. The whole outfit presents a fine appearance, and the large outlay in the new plant has been warranted by the exposure of extensive bodies of ore. This mine, from present showings, may be regarded as one of the most valuable mining properties owned by the company.

Evans mine.

The last of June I spent considerable time in going through the Evans mine, accompanied by Captain Alfred James, and I found the workings in good condition. About fifty men were then employed in and about the mine. Since my previous inspection in September considerable work had been done in the first level, or large open pit, from which about 1,000 tons of ore had been lifted. An equal quantity had been taken from the second level, and a winze had been opened between the first and second levels. Stopes had also been made in the third level, from which about 1,000 tons of ore had been mined. In the fourth level considerable stoping had been done both north and south of the shaft, and some 2,000 tons of ore secured. A winze was opened connecting the third and fourth levels. On the fifth and lowest level a sump has been sunk eight by twenty-six feet and nine feet deep, to receive the accumulating water, at which point the pump is placed as described in the former report. Both north and south of the shaft limited stopes have been made and about 800 tons of ore removed. The total depth of the workings is 275 feet from the surface, and with a good showing of mineral. For process of treating the ore see former reports.

Extent of the workings.

In November I again inspected the mine and found it in a safe state, with the usual force of men employed, under the direction of Captain H. Davis.

who has but recently taken the place of the late Captain James, and who has had thirty-five years' experience in the management of mines. I directed the attention of the captain to the exposed condition of the large open pit adjoining the rock house, and the following day he had it securely fenced.

Accident.

An accident occurred on the morning of October 23rd in the shaft of this mine, at the third level. James Sheedy, a young workman, was attempting to lift the gate by hand, when the cage descended on him and seriously injured his back. A hook was provided and generally used for raising the gate, and had Sheedy taken advantage of this the accident would have been averted. Due care was taken of the injured man, and after the lapse of a few days, upon the advice of the attending physician, he was sent to the General Hospital at Toronto. Three or four weeks after the accident the resident physician informed me that he was slowly improving, and that in time he would most likely entirely recover from the injury. Sheedy spoke in terms of highest praise of the consideration shown to him by the company, and also informed me that all his expenses were being defrayed by them. He stated that the accident happened through want of forethought on his own part.

Dominion Mineral Company.

I visited the Blezard mine in June. The mining was being done in the open pit, in which were twenty-five men on the day and night shifts, and about eighty-five tons of good ore were taken out daily. The main portion of the roof had been removed and all the pillars, excepting the shaft pillar, had been thrown down. Seven or eight thousand tons of mixed rock and ore were lying on the floor of the opening. The hoisting was being done by steam derrick. The standing walls had been been well trimmed, and the work was being carried on with safety. It was intended during the summer to take out this large mass of material, and also to take down the shaft pillar. No work was being done below this point, and the shaft was covered over.

Blezard mine.

The timbering in shaft No. 4 had been completed and a good cage put in for lifting ore. No additional sinking had been done. A cross-cut had been made in the west drift, about sixteen feet from the shaft, and a stope made from which a small quantity of ore had been taken.

Smelting operations.

The smelter was treating from 120 to 140 tons daily, varying with the different classes of ores; twenty-eight men were employed in this department. About 14,000 tons of ore, roasted, or in process of roasting, were on hand, 3,000 tons of which had been brought from the Worthington mine. The magazine is situated half a mile distant from the mine. About 7,000 cords of wood were in the yards.

The work was being carried on with a total force of 140 men, economically and with safety, both in the mining and smelting departments.

The manager, Mr. Ian Cameron, rigidly enforces the sanitary rules, and no epidemic prevailed at the place.

In November, when I again visited this location, both mine and smelter were closed down, but I am informed by a recent letter that both will be reopened during the coming spring.

Worthington mine.

The Worthington mine was discovered at the time of the construction of the Canadian Pacific Railway, by the gentleman whose name it bears, Mr.

James Worthington, who was then a contractor for building a portion of the railroad stretching by this property. He still continues to be one of the large shareholders and is a director of the company now owning and operating it.

Extent of the workings.

At the date of my inspection, at the end of June, Mr. Cameron, the manager, accompanied me to the mine, where a force of thirty-five men was employed under the direction of Captain R. McBride, chiefly engaged in development work and taking out about 15 tons of ore per diem on the day and night shifts.

Shaft No. 1 was sunk to the depth of 140 feet, and from the surface neatly timbered down fifteen feet to the solid formation. The first level, at fifty feet from the landing, was driven in thirty feet west, and a small stope made. Levels are driven in at 110 feet from the surface, both east and west, the former to the distance of twenty-one feet and a communication made with shaft No. 2, thus affording excellent ventilation. Shaft No. 2 was not being used, the ore being lifted in shaft No. 1.

In the west drift, at a distance of forty feet from the shaft, a cross cut was being made at this date. Work was also being done at the bottom of the shaft, thirty feet below these levels, sinking in an excellent body of ore. A ladder way was being put up, which was partly walled off from the shaft, with rests twenty feet apart. Steam power was used for hoisting the buckets. A good cage hoist would be provided as soon as stoping was done to any considerable extent.

Machinery

The machinery consists of two boilers, a double drum hoist and an engine to drive the large Blake crusher, capable of breaking 100 tons of rock in ten hours.

and buildings.

The buildings are a shaft house twenty by thirty feet, with adjoining rock house thirty by thirty-two feet, floored with steel plates; engine house thirty by forty feet; blacksmith shop and stabling, boarding house and office and six dwellings. The magazine is situated half a mile from the mine.

The ore shipped to Blezard mine.

After the ore is sorted and crushed it is loaded on cars and taken via the Canadian Pacific Railway to the roast yard at the Blezard mine, a distance of thirty miles, and prepared for the smelter. Smelting works, it is expected, will be constructed at this mine at a not distant date. A large percentage of the ore removed continues to be of high grade. Work was suspended at the mine for some time during the latter part of the summer, but was recommenced in November with a considerable force of men and has since been vigorously carried on.

A communication from the captain of the mine of recent date states that a third level has been run in a short distance, and also that the principal place of working was in the raising chute stope connecting shafts Nos. 1 and 2, from which place they were getting at present the bulk of the ore.

H. H. Vivian & Co.

My first visit this year to the Murray mine was in the latter part of June, and the management was the same as the previous year. Work had been suspended before the close of 1892, but was recommenced in April last. Sixty men were employed in the mining department under Captain Richards,—thirty-one on underground work and twenty-nine above ground.

Murray mine.

Three improved Ingersoll-Sargent drills had been added, and five were in use in the mine. About the usual quantity of ore was being mined, and of similar grades as formerly reported. The ore is taken out by contract. The mine was in a safe condition.

In November I again examined this mine. Captain Richards had a special outside appointment, and foreman George H. Behenna accompanied me through the mine. The latter gentleman has had extensive experience in mining,—first in the Cornwall tin mines, and since in Alabama, Montana and Michigan mines. The mine was in a safe condition, and conveniently arranged for work in addition to its neatness. A short space of the ladder-way required walling off, which Mr. Behenna informed me would be immediately done. The work done since my previous inspection was in drifting and stoping, and large bodies of ore were exposed. It is intended to sink the shaft an additional fifty feet during the winter, and explore the mineral at greater depths. The deepest working at present is 100 feet from the surface. At this date fifty men were employed on the day and night shifts in the mine, and seventy-five tons of ore lifted daily. Four air compressor drills were being used.

Extent of the underground works.

At my request, Captain S. Richards has kindly furnished the particulars of the nature of occurrences, method of operating the mine and the extension of work, bringing it up to the end of the year, together with the appliances used, the interesting descriptions of which are herewith inserted.

Occurrence of the ore.

Respecting the nature of occurrences he says: "The ore body, which possesses an average thickness of seventy feet, strikes in the direction N. E. and S. W., and dips north-westerly forty-five degrees from the horizontal. This agglomerated mass of nickeliferous pyrrhotite and diorite is contained by diorite walls. The foot wall at certain points, as proved by mining operations, presents the appearance of a true fissured plane upon which, at some time or other, the ore body has moved, as evinced by the coarse flucan or attrited matter which separates the ore from the wall. In some places through the occurrence there exist large inclusions, horses or intrusions of diorite containing fragments of granite. These from their size and extent often render mining operations in their vicinity unsatisfactory when considered from a commercial standpoint."

Method of working the mine.

On the method of operating he says: "Our system of mining has hitherto been a modification of the cross-cut method with solid pillars. A shaft is sunk vertically on the occurrence, and drifts at the different levels are extended along the foot wall, the drifts at one level being connected by winzes and rises with the level above. Cross-cut stopes are then advanced from the foot wall to the hanging, leaving solid blocks or pillars between levels, and from wall to wall. These are cut through at intervals, forming arched excavations and sufficient material remains in situ to support the roof and overhanging wall. When convenient the larger intrusions are allowed to stand as pillars, but as nature bestows some of her gifts at too frequent intervals some of these barren rock masses are found when and where they are not wanted."

Extent of recent working.

On recent work he says · "The company has at great expense installed a water supply from a lake one and a half miles distant, and contrary to former winters work has been carried on almost uninterruptedly during the present season. Since last report (printed) at the second 100-foot level we have further extended our N.E. drift ninety feet, thus making on this side of No. 6 shaft a drift 125 feet in length. The drift is being continued. About thirty feet from the mouth of the drift a rise has been put up to the first level, and stoping from its sides is being done. At thirty feet from the breast of the drift another rise has been started, which is at the time of writing half way or twenty feet through. Shortly this rise will be holed to the first level, and more stoping ground will then be available. On the other side of shaft No. 6, at the 100-foot level, the S. W. drift has advanced sixty feet, making on this side eighty-eight feet of drifting. At a suitable distance from the mouth of the drift a winze connects the workings of the first and second levels, and stoping is progressing. The S. W. drift is still going ahead. The small drift mentioned in former reports is in reality a cross-cut, and this has been driven thirty-five feet further ahead, making in all seventy feet cross-cut in ore. We have commenced to sink below the second level, and are now eight feet down. We purpose to sink down to another level and prove by cross-cuts and drifts the nature and extent of the ore body at a lower depth. Stoping is being done at the first level as formerly."

Appliances.

On appliances he says: "We have in use five compressed air drills. Drifting is done by hand labor. The mine is worked both by day and night, whilst crushing and sorting at the surface is done in the day time. About seventy men comprise the force at the mine, and thirty-seven of these are employed underground."

Miscellaneous notes.

The smelter had been closed from the end of January to the beginning of May. At the date of my visit they were running at the rate of 1,600 tons monthly. The bessemerized matte was shipped weekly. Ten or twelve thousand cords of wood were on hand. A total force of from 120 to 150 men were employed at both mine and smelter. Nothing had been added other than repairs and what was necessary for efficiently carrying on the work. The sanitary condition of the place was good. In the day school seventy scholars were enrolled. A neat church edifice had been built recently, and religious services and a Sabbath school were conducted every Lord's day.

In November I again went through the whole of the works, when the smelters were in full operation and all apparently was in excellent shape.

Mr. Henry W. Edwards, metallurgist, who has charge of this department of the company's work, has supplied an interesting description of the management of the ore—the process and requisites for smelting, with improvements, and labor employed, which I am permitted to subjoin.

Further details of processes at the Murray mine.

"The ore is received from the mine in small cars each carrying about one ton, running upon an elevated track raised by means of trestles some twelve feet above the level of the bottoms of the roast heaps. The floor of the roast heap is prepared by laying first a layer of six inches of small ore and upon this a layer of cordwood about eighteen inches thick. Upon this layer of wood the ore is dumped from the elevated track. About 1,000 tons of ore form a roast heap. The heap being completed, the wood is ignited and fire is soon communicated to the ore, which will burn on an average for ten weeks. There is always a stock of some 6,000 tons of ore in heaps being built, burning and cooling, and being broken up for delivery to the smelting shed. The cost of mining and burning this large quantity of ore and carrying it in stock for so many months is in itself a heavy charge upon operations here.

The roast heaps.

"As soon as a roast heap has finished burning and has cooled off it is torn to pieces and is transported in convenient quantities to the smelting shed, where there are two furnaces having a collective capacity of 160 tons of burnt ore daily. The fuel used in these furnaces is coke from Pennsylvania, which is much cheaper than Nova Scotia coke on account of the heavy freight upon the latter. In order to put the Nova Scotia coke on a footing to compete with that of Pennsylvania, a protective duty of at least twice the value of the coke at the ovens would have to be imposed, the present duty of fifty cents per ton being only an annoying burden of no benefit whatever to the Canadian producers.[1] In its transit here the coke has to pass over several railroads, and is subject to so many delays that we have to carry a heavy stock of it to insure that there shall be no interruptions of the smelting for want of fuel.

Fuel for the furnaces.

"The burnt ore is smelted in the usual manner in small blast furnaces, the fused products being two in number, viz., slag, which is thrown away, and matte, which is passed on to the Bessemer process. The Bessemer plant at the Murray mine is the first of its kind applied to the treatment of nickel matte, and great efforts have been put forth to bring it to a successful issue. One of the materials required in this department is a good quality fire clay, which we have not been able to find as yet within our reach in the Dominion; we therefore import it from Ohio by the schooner load during the navigation season. The bessemerized matte is shipped to H. H. Vivian & Co's. smelting and refining works in Swansea, Wales, where the concluding operations are carried out.

Application of the Bessemer process.

"During the present year the following alterations and additions to the plant have been made: (1) A steam pump and boiler at a small lake a mile and a half to the south, and a pipe conveying the water thence to the smelting works. This has been forced upon the company by the very bad quality of the water near at hand. (2) An extension of the roasting floors to accommodate a further quantity of three thousand tons of ore. (3) A new multi-tubular boiler of 100 horse power.

Alterations and additions to the plant.

"The engines employed in the smelting department aggregate ninety horse power. There are sixty men employed, about two-thirds of whom are unskilled laborers; the remainder are skilled workmen.

Labor.

"During the year 1893 there have been three casualities, two men slightly burnt and one man severely."

Accidents.

Recently operations have been resumed on the property of the Drury Nickel Company, after it had been lying idle for nearly a year, with a force

Drury Nickel Company.

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[1] Under the amended Tariff Act of 1894, coke is put on the free list. This was done in response to petitions from mining companies and miners in the Sudbury District, and a memorial from the Toronto Board of Trade.

of about twenty-five hands under the direction of Mr. R. P. Travers. With the present output of ore and the quantity on hand when the mine was closed down the smelter will be kept constantly running. It is stated that the company's prospects are now encouraging, and that orders have been received for the entire quantity of matte to be produced for some time to come. For description of mine and plant see former reports.

Sheppard or Beatrice mine.

The Sheppard mine is now called the Beatrice. This property comprises 320 acres, being lot 1 in third concession of Blezard, and is held in fee simple. A limited amount of prospecting on it had been done previous to the purchase by Messrs. Thomas Sheppard and E. H. Davis of Montreal, of the property from Mr. Babcock, who made the discovery of the nickel deposit in 1890 and immediately located it. The present owners have opened up the property by sinking a shaft 10 by 12 feet to the depth of 100 feet. At 40 feet from the surface two drifts have been run in east and west from the shaft, each about 10 feet. Below these drifts another has been run in 14 feet north. Mineral was followed in the shaft to the depth of the lowest drift. Each of the drifts has been in mineral, showing the existence of a large body of ore. Eight hundred tons of high grade nickel ore have been taken out and marketed in the United States, and there remains a quantity of lower grade on the dump at the mine.

Work was commenced by the present owners in 1891, and vigorously prosecuted in 1892 under the management of Mr. E. S. Townsend, who assumed control in February of that year. Work was continued with a force of about 30 men until April last, since which time the mine has been lying idle. In November, at the time of my second visit to that locality, it was expected that work would recommence at an early date.

The shaft is well timbered to the depth of 30 feet, at which point solid formation is reached. Work when resumed will be carried on in the drifts, as the lower part of the shaft was in barren rock.

A good road has been constructed to the Blezard mine, a distance of two miles in a southerly direction, over which the ore was hauled by sleighs in the winter to the point of shipment on the cars. For description of plant see former report.

Tam O'Shanter mine.

In a recent issue of the Sudbury Journal it is stated that some English capitalists are negotiating for the purchase of the Tam O'Shanter property, which is in the township of Snider, three miles from the Copper Cliff and six from Sudbury. The discovery was made last season, and from present appearances there is a large body of mineral, the surface ore running as high as 3½ to 4 per cent of nickel.

The October number of the Canadian Mining Review contains a description of "Our Mineral Exhibits at the World's Fair" from which the following interesting extract is taken :

The mineral exhibit of Ontario at Chicago.

"The whole of this section was well worth seeing. Ontario had a strikingly good exhibit. This go-ahead Province certainly did credit to herself. Mr. A. Blue, Director of Mines, Commissioner Awrey, and the able staff of which Mr. Boyle was a conspicuous figure, have reason to be proud of the result of their months of arduous labor. The Ontario court presented an attractive front, and the nickel trophy in the centre formed a unique and massive pyramid, impressive to the sight, and never to be forgotten by the passer-by. Iron ores, copper, mica, graphite, zinc, galena, asbestos, building stone, petroleum and its products, fire and brick clays, soapstone and apatite, or phosphate of lime, with its products, were shown in abundance and tastefully and artistically displayed. Due regard to the economic aspect of the exhibits was to be seen on all sides. The gold and silver ores also formed salient features in this court, whilst salt, marbles, sandstones, granites, clays and cement stones served to complete the exhibits of the Province whose mineral wealth is only now just being appreciated. Ontario's display of its mineral wealth was indeed an instructive one. To the economic collection was added a mineralogical one of considerable extent, furnished by a private collector in the person of Mr. W. G. Kidd of Kingston.

The nickel trophy.

"The nickel trophy deserves more than a passing mention. It was undoubtedly the most complete and extensive display of the kind ever made in the world. The exhibit of the only country which could compete with Canada was New Caledonia, a colony of France, and whilst its exhibit was certainly instructive and interesting, yet it was small and inconspicuous Some of Ontario's specimens of nickel ore weighed 6,000, 8,000 and 12,000 lb. respectively, and gave a capital idea of the extent and richness of our far famed nickel deposits. Nickel anodes, nickel shot plates and ingots of nickel were also exhibited."

IRON ORES.

The following, taken from the Kingston Whig, is of interest, in view of the probable early access to the markets of the United States for our iron ores:

Wilson mine.

The iron ores on the Kingston and Pembroke railway.

"To-day G. A. Longnecker and John Morris of Pennsylvania were in the city. They purchased a car-load of magnetic ore, which will be got at the Wilson mine near Calabogie. The ore will be taken to Pennsylvania, tried in the furnace, and if the test is satisfactory they will buy an iron ore property in the vicinity of the K. & P R. It is thought a boom in the iron ore business is close at hand. It will begin when the duty is taken off iron ore going from Canada to the United States. This change may be made by the Cleveland Administration, and some iron men are confident the duty will be removed."

Atik-okan iron range.

"On valuable outcroppings of the Atik-okan iron range, lying along the Atik-okan river in Ontario, nearly a hundred miles north of the Minnesota boundary and fifty miles from the Canadian Pacific line, options were given three years ago to a Belgian syndicate, reported at that time to be of great strength. These options expire with October 31st, but arrangements are being made looking to a continuance. The Belgians are waiting for a decision in tariff changes, particularly on the import of iron ores, before closing their purchase." For the above I am indebted to the N. Y. Engineering and Mining Journal.

The following excerpt is from an excellent article on iron mining in Ontario, which appears in the April number of the Canadian Mining Review: "No one who considers the situation with an unbiased mind can do otherwise

Freer trade relations a necessity.

than come to the conclusion that in whatever way freer trade relations with the remainder of this continent would affect other industries and interests in Ontario, they could have none but beneficial results upon iron mining. The close competition which the opening up of the new sources of supply within the past few years has given rise to in the United States markets has made it impossible to raise iron ore and ship it across the lines in face of a duty of 75 cents per ton, and the result is that the iron mines of central and eastern Ontario within easy distance of the great smelting centres in Ohio and Pennsylvania have been forced not only to cease raising ore to the surface, but have even in some cases been obliged to keep on hand considerable quantities which had accumulated at the mouth of the mines when last in operation. Were commerce as free between Ontario and the United States as it is between Michigan and the rest of the Union, it is surely reasonable to suppose that results would ensue in Ontario similar to those which have followed in Michigan. Not only could iron ore be exported, which in itself would be a very great boon, but with a large outlet for charcoal iron, for the production of which the facilities possessed by Ontario are unequalled, the business of smelting would receive an impetus which could not be imparted to it in any other way. The report of the Commission on the Mineral Resources of Ontario (1890) sums up this aspect of the situation very concisely in the following words: 'The beneficial influence to be exerted upon the interests of the Province by the stimulating effect certain to be the result of the breaking down of the hostile tariffs between Canada and the United States would, in the case of the export of iron ore, and probably of pig iron also, be certain to promote the prosperity of Ontario to an extent greater than any but the most sanguine would venture to predict.' "

MICA.

Sydenham mine.

The Sydenham mine is situated four miles by water and eight by road from the village of Sydenham. It was formerly owned and worked by Lacy & Smith, but has been lying idle for a couple of years past. The property embraces one hundred acres, and a part of it is worked for agricultural purposes by the present owners, Messrs. Webster & Co., who purchased it in December last.

The head office of the present company is in Kingston. Work was begun by Messrs. Webster & Co. on the 1st of January last, under the management of Mr. J. E. Chown of Sydenham, with Captain John Harris as foreman, who had the former charge for eight years when worked by Lacy & Smith. It was in fairly good condition, but required the refitting of some ladders, walling off the ladder-way from the shaft, and putting in a few additional timbers in insecure places, all of which the foreman assured me should have early attention. The recent heavy rains had caused a good deal of dripping, and the accumulation of a large quantity of water, but the Cameron pump in use discharged it with ease.

Extent of the workings.

The main shaft had been sunk an additional 20 feet, making a total depth of 180 feet. In the 100-foot level the drift had been extended eight feet, making its total length in an easterly direction from the shaft 200 feet. A few tons of mica had been obtained from this cutting. Stoping had also been done in this level, with a good yield of mica. At the distance of 95 feet from the main shaft an open cut had been made 8 by 24 feet and 30 feet deep, and the foreman stated that an excellent deposit of mica had been exposed, but the work at this point was abandoned on account of the inflow of water. Another opening south about 200 feet from the first, 10 by 25 feet and 18 or 20 feet deep, was being worked, from which about three tons of amber mica had been taken out. The mineral showing at this stage of the work was good. A horse derrick was used. Considerable prospecting on the lot had been done by stripping and cross-cutting, with excellent showings of mica. All surface drilling was done by hand. The old buildings and machinery are being utilized for present operations, and the boarding house and office have been nicely refitted. There is also a store, a shaft house with annex for boiler and engine, a cobbing house with bedrooms attached, a house for changing clothes, and a blacksmith shop, etc. The magazine is about 300 feet from the other buildings.

The hoist is by bucket with guides, and holds about 1,000 pounds at a lift. By an excellent automatic arrangement the mineral is dumped into a hopper, from which it runs into a car and is conveyed over a tramway to the cobbing house or to the dump. After being roughly sorted it is taken either by scow across the lake, or carted by road to the mica house in Sydenham, where it is carefully sorted and boxed or put up in barrels for shipment.

A 35 h. p. boiler with engine is used for pumping and hoisting. Two Ingersoll air compressor drills were in use. Twenty men were employed in May at the date of my visit, fifteen at mining and the others at outside work; the former receiving $26 and the latter $20 per month with board.

About 300 cords of wood were on hand, two cords being used per diem on the day and night shifts.

Levett & Davis mine.

On May 22nd I visited the Levett & Davis mine on lot 3 in the fifth concession of Burgess, on the shore of Rideau lake, 7 miles south of Perth. Recently the mine has been purchased by Messrs. Levett & Davis, and they had been working it with a force of seven men for six weeks, during which time about twenty tons of amber mica had been mined and taken via the lake to the mica house at Perth. It is there dressed and boxed. About eight tons were on hand at the date of my visit, the rest having been sold. Excellent facilities are had for loading the ore, as the shore is so bold that the small steamer John Haggart which plies on the lake can moor at its edge.

Working on the property.

In former years the property had been worked for both mica and phosphates, and considerable quantities had been taken out. The surface workings have been extended over 20 or 25 acres. The principal place of working is about twenty rods from the landing, where an open pit has been sunk about 25 feet, with surface opening 20 by 30 feet, and narrowed to 10 by 20 feet at the bottom. I examined several other openings on the property from which fine crystals had been taken, three of which were some thirty rods from the main workings. The vein of mica is from 8 to 10 feet in thickness, and some very large crystals have been removed, one lump being two by three feet and weighing 450 lb. The present developments indicate a large output as the work proceeds.

A good boarding house was in process of construction at the shipping point on the lake, to which would be annexed an office; also a building for storage with good stabling attached, a blacksmith shop, etc.

Mr. Levett has the general management, and Mr. A. Gibson charge of the ground work.

Martha mine.

On May 22nd I visited the Martha mine, which is situated on the north-east half of lot 13 in the sixth range of North Burgess, a distances of ten miles south of Perth. Surface prospecting work had been done at intervals since 1871, extending over about 40 acres for phosphate, and a very considerable quantity had been taken out by the several operators. In December, 1892, the property was purchased from Mr. D. George MacMartin by the Lake Girard System, a company having its principal office in Ottawa. The present owners have worked the property since early in January last with encouraging results for both amber mica and phosphate under the management of Mr. MacMartin, with Peter Powers as captain of the mine. The mica is carefully culled, hauled to the town of Perth and shipped via the Canadian Pacific Railway to Ottawa. The phosphate obtained is of excellent quality.

Works and machinery.

The place of working at the time of my visit was on the rear of the lot, which contains 100 acres, the mineral right only having been purchased by the present owners. In an open pit, 33 by 40 feet and 32 feet in depth, sixteen miners were engaged at work, but the total force employed was twenty men. The rock was lifted by two whims worked by horse power. No brakes were used, but two suitable ratchets had been provided, which I was informed would be immediately attached to them. From 40 to 50 tons of mineral and rock were being taken out daily. This mine gives promise of an excellent yield. Six or seven hundred cords of wood had been provided, and suitable machinery with which the work could be conducted on a much larger scale would be brought on at an early date.

The old boarding house would soon be displaced by a large new one, then in process of construction, at the distance of a quarter of a mile from the other. A good magazine had been put up 200 yards from the workings. Good stables, a blacksmith shop, etc., had been built. Stanleyville P. O., Lanark County.

O'Connor mine.

Mr. Anthony O'Connor owns in fee 100 acres of lot 1 in the third concession of South Burgess, on which he was mining for mica with a force of five men when I visited the place in May. A little prospecting had been done the previous year. For about six weeks work had been carried on and an opening had been made 25 by 36 feet and worked to the depth of 22 feet. The mica vein at the place of working is about ten feet wide, and by about one hundred in length, and five or six tons had been taken out and sold. A derrick is used for lifting the rock and ore. Several other surface openings show mica, and in one a body of graphite has been exposed. This property is 2½ miles south from Hagarty's Wharf, and 4½ miles from Oliver's Ferry.

O'Mara mine.

The O'Mara property comprises 100 acres, being part of lot 5 in the first concession of South Burgess, and is owned by Mr. James Jones in fee simple.

The mineral right has been leased by Mr. Patrick O'Mara, and the mine has been worked by him with a force of four or five men since December last. Up to the date of my inspection in May, 25 tons of mica had been mined. The ore is culled at the mine, a part hauled to Perth, a distance of fifteen miles, and the remainder to Oliver's Ferry, six miles away. A portion of it has been marketed in Boston, Mass., and the rest in Kingston. The ore when culled is separated into three qualities, the value of which per ton is stated to be as follows: No. 1, $250; No. 2, $110; No. 3, $25. About equal parts of No. 2 and No. 3 were obtained, and a lesser proportion of No. 1.

Work was being done on the northerly part of the lot, and an open cut had reached the depth of 35 feet, with some additional surface stripping, exposing a fair showing of colored mica. The lifting is done by derrick. Very little water interferes with the workings. Mr. Peter Adams supervises the work at the mine.

A mica house, blacksmith shop and stables have been built. Cranworth P. O. is within half a mile of the mine.

Canton mine.

On May 23rd I visited the Canton mine, situated on lot 1 in the fourth concession of South Burgess. Mr. J. E. Chown of Sydenham has the general management for the owners, Messrs. Webster & Co., who have purchased the mineral right of 100 acres. Five men and the foreman, Mr. Samuel Cordick, were clearing out some old pits, preparatory for more extended work on the mine, which is now being worked chiefly for mica. Formerly a considerable quantity of phosphate had been mined. A portable boiler and engine had been brought on, to be used for pumping water, drilling and hoisting at the workings.

Workings on the location.

One opening of 22 by 37 feet at the surface and narrowing towards the bottom had reached the depth of 40 feet, but was now nearly filled with water. Last fall 40 tons of phosphate, with some mica, were taken from this cutting, which was then worked for two and a half months with a force of fifteen men. Several other openings for over 100 feet on the surface had been made, on which work will be continued for mica, as the showing is good.

This property is about 100 feet above the surface of the lake, and yet the inflow of water in the cuttings is a serious impediment to the work.

I had the pleasure of meeting Mr. Watson of Boston, one of the principal members of the company, who was carefully examining the property, as well as the old Smith & Lacy mine, which the company had recently purchased.

The description of the two following properties is given in the Ottawa Mining Review for December:

White mica in Calvin.

"Mr. John McKay of Eau Claire is working his lot, No. 9 in the first concession, township of Calvin, for white mica. The crystals are irregularly distributed in veins of a coarse granite, which have a general northeast-southwest direction, and vary in width from four feet up to 25 feet. One vein, with elliptical section shows a length of 110 feet, and an average width of 15 feet. The crystals taken ont of this vein have a light green color, and the single laminæ contain frequently green spots; they are not very large in size but yield a good average of clear sheets. The vein has been tested by a shaft of 25 feet depth, and it seems to continue regularly. Another vein in the north part of the property has a width of 25 feet, and has been traced for about 450 feet. The output for three months, with an average labor of five men, amounted to 3,500 lb, which have yielded 25 per cent. of trimmed mica.

"Mr. F. B. Hayes of Ottawa has been working for about two months on lots No. 16 in the first and second concessions of the township of Calvin. Six parallel veins containing white mica crystals distributed have been uncovered. The principal opening consists of an open cut of 30 feet by 10 feet wide on a mountain slope. Work has been suspended for the winter on account of the heavy snow fall. The quantity and quality of the mica taken out give reason to believe that the property, if developed, can be worked with success. Operations will be resumed next spring."

GRAPHITE.

Graphite in North Elmsley.

At the time of my visit to a graphite property in the towship of North Elmsley in May work was being conducted under the management of Mr. John F. Torrance, of Montreal, a graduate of the Arts and Science department of McGill College, as well as of the School of Mines at Freiburg, Saxony. He has visited the mining districts of East India and British Columbia, and has also acted on the Geological Survey of the Dominion.

Mr. Torrance informed me that application had been made by Montreal and Boston capitalists for a charter for a company to be known as the Northern Graphite Company, with a capital stock of $95,000.

Six or eight men were actively engaged in sinking bores on lot 22 in the sixth concession of North Elmsley, which is out from Perth about six miles, and one mile from Oliver's Ferry. Bores have also been made on lot 21, and one bore on lot 23 in the seventh concession. The Company has leased 1,200 acres with the option of purchase, some of the lands lying on both sides of the Rideau. The formation is chiefly limestone. In all eight bores had been put down, averaging from 50 to 100 feet in depth. The surface showings were excellent, and the borings confirmed the existence of graphite to the full depth to which they had been sunk. Some of the cores also gave showings of considerable deposits of phosphate.

The rock is ordinary gneiss, associated with limestone. The bands of gneiss contain the graphite. On lot 22 the formation is anticlinal. There were good surface showings of graphite on lot 1 in the sixth concession of Burgess, which were going to be fully tested.

GYPSUM.

Paris mine and mills.

Early in December I visited the Paris plaster mine and mills. At the latter about a dozen men were employed. No change has been made in the process of manufacturing alabastine. The demand for it has increased fully 50 per cent. during the year. It is prepared in the form of a fine powder, then put up in 5-lb. packages and is ready for use with the addition of cold water only. It is largely taking the place of kalsomining, papering and other finish upon house ceilings, walls and other surfaces, making a permanent and neat coating. It is as hard as the wall itself, and when necessary can be replenished by another coating of the same material without the old being removed. Before being put into packages it is prepared in different colors to suit the taste of those using it. Directions accompany each package, and it may be applied by any party needing it. Another article, used for the extermination of potato bugs, is prepared at the mill. It consists of plaster, Paris green, and other material ground together, a product new in Canada but widely used in the United States and extensively prepared at Grand Rapids, Mich. It is put up in barrels containing 300 lb. each and labelled "Church's Potato Bug Finish."

Alabastine.

A new plant for calcining the plaster, of about one ton capacity per hour, has been put in the mill during the year by Mr. Hare, who has charge of the milling department. After the plaster is ground by the buhr stones it is elevated into a hopper, from which it is introduced by a feeder into the long fire box, and by a lateral worm conveyor it is slowly carried along about 40 feet and returned by a similar process through the fire box, making its transit of 80 feet subject to an intense heat. The plaster is thus evenly and thoroughly calcined by a continual flow. The fire box is heated by gas oil, of which a barrel containing 40 gallons is used in ten hours. The demand for this article has largely increased during the year. It is now being shipped in car lots to Toronto and other places for sale. The white gypsum from which this is manufactured is brought from the beds on the Grand river in the vicinity of Cayuga. This is the only plaster calcining establishment in Ontario.

A new process of calcining plaster.

I directed that an open cage entrance on one of the flats with a stairway and one belt should be fenced off with proper railings.

Three men were working in the mine by contract at 90 cents per ton, taking out about five tons daily. The new drift referred to in the former report had been abandoned on account of the inflow of water. An important change has been made in the old drift by which the present approach to the face of the deposit was shortened to half the distance of the old one, and much better ventilation in the mine secured. At the place of working the layer of plaster was about four feet in thickness and opened to the distance of 200 feet. I advised that a cross-cut be made to ascertain the extent of the deposit, and if the field of mineral was found to be extensive then to reconstruct the drift at once. It is low and inconvenient, and requires additional supports. The roof at the place of working was fairly well supported. Some parts of the old workings had broken down. About 1,000 tons of gray plaster had been taken out and ground during the year for fertilizing purposes. Some 300 tons ready for sale were still on hand. It was expected that double the quantity would be mined in the coming year.

Mining the gypsum.

Mr. T. W. Wheeler continues in the management of the company's operations in Canada.

Excelsior mine is on lot 2, Grand River road, 2½ miles east of Cayuga. It is owned by the Adamant Manufacturing Company of Syracuse, N.Y., and is now leased by the Alabastine Company of Paris. This lease expires

Excelsior mine.

on August 1st, with option of renewing. Mr. John A. Nelles has the management of the mine, and had been working it on contract with a force of four men since September 1st. At the date of my visit, December 12th, 200 tons of white plaster had been mined, and was being delivered at the Cayuga station on a contract of 1,000 tons to be used at Paris for adamant purposes. Mr. Nelles provides all the material for operating and keeping the mine in a safe condition. Some parts of the mine required repairs, as the property had been lying idle for three years until the recent working. The small quantity of water that runs into the mine is drained into two sumps, over which pumps driven by windmill power at the surface are used. These when in good condition for work have proved sufficient. At each pump shafts have been sunk from the surface, and are well timbered up, affording a safeguard against accident as well as excellent ventilation to the mine. The tunnel is run in from the level surface in a northerly direction at a dip of one foot in ten for the distance of 175 yards, where it intersects the bed and continues an additional 200 yards, following the layer of plaster. At the foot of the incline 175 yards from the entrance another drift has been extended on an easterly course for 200 yards to the place of the present workings, which is at a depth of 60 feet from the surface. The gypsum is hauled out by horse car over the tramway.

Teasdale mine. Teasdale mine is situated four miles east of Cayuga, on the Grand river. Three men were engaged at the mine and were taking out about six tons per day of white gypsum at the date of my visit in December. Only one ton of waste rock was broken out to ten tons of plaster. The drift is started in a ravine three or four feet above high water in Nolan's creek, and is driven in at an incline of one foot to the 100 feet. At the distance of 100 yards from the entrance a pump is placed, driven by a windmill on the surface, which is 35 feet above the workings at this point. The drift is continued in the same south-westerly direction another 20 yards to the present place of working, at a slight incline upward, giving drainage in both directions to the pump, which is of sufficient capacity to keep the mine free from water when running. The uncertainty of the power prevents working the mine continuously. Great care has to be exercised in not breaking up the floor of the drift, which is of solid rock, as there appears to be a fountain of water some two feet below, which upon being opened quickly floods the mine.

The continuance of the drift with its present upward incline may overcome the water inflow which has hitherto seriously impeded the work. The layer of gypsum, which is from three to four feet in thickness, follows to some extent the surface incline upward. It is supposed that the large quantity of water underneath the plaster is retained by the dam placed across the river at Dunnville, ten miles below the mine.

Two test shafts on the top of the hill have been sunk to the bed, some distance apart, which would indicate that the plaster extends over a wide area. About 400 tons have been taken out of the workings, of which nearly 100 tons remain at the pit's mouth ready for shipment. A horse tramway is used in taking out the mineral, a car load being 1,500 lb.

The property is under lease by the Alabastine Company of Paris and the mining is done under contract by Mr. John Walton, who furnishes all requisites to keep the mine in order. The drift is well timbered and the work carefully conducted.

Martindale mine.

I inspected the Martindale mine on the 13th of December, when but two men were employed in mining. About 250 tons had been taken out during the year, and about five tons daily were being removed at this date. Some parts of the old workings had settled down, and others had been abandoned on account of their unsafe condition. A few places in the long drift leading to the present working ground required refitting, the timbers having become weakened by decay. This mine requires a thorough overhauling, the expense of which the workmen, though mining by contract, claim should be borne by the owner, who apparently is indifferent about it. I requested that some of the more dangerous places in the drift should be secured at once, which the men consented to do. The immediate place of working was well supported.

Garland mine.

At the date of my visit to the Garland mine in December, two men were employed by contract at the works. The place of working was 150 yards from the entrance, and the mineral was taken out by horse tramway at the rate of six or seven tons daily. It is ground in the mill at Caledonia, and is used largely as a fertilizer. The layer of gypsum of about four feet in thickness is overlaid with a bed of firm clay or hard pan, which in places as the gypsum is removed softens on coming in contact with the air and settles down into the space below. Much care has to be taken to secure the roof at the places of working, which is done by building up walls of the waste rock and timber supports.

Upon close examination I found many of the small timbers in the entrance drift in a very decayed state. I gave instructions to the contractor to have them replaced with firm supports, and also wrote to the owner of the property, Mr. Nicholas Garland of Toronto, stating the dangerous condition of this part of the mine. There is yet a large field of gypsum in this property.

The Merritt, the Glenny and the Mount Healey mines are lying idle.

I have the honor to be, Sir,
Your obedient servant,

A. SLAGHT, Inspector.

Waterford, February 10, 1894.

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Hon J. G. Bourinot

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1. Map of the southeastern part of the Rainy River district, exhibiting the country in the vicinity of Rainy lake and river Seine. Scale, 2 miles = 1 inch.

2. Map of part of the Rainy River district, exhibiting the country in the vicinity of Manitou, Eagle and Wabigoon lakes. Scale, 2 miles = 1 inch.

The maps show all mining locations filed in the Department of Crown Lands to 1st June, 1895.

To His Honor **George Airy Kirkpatrick**,

Lieutenant-Governor of Ontario:

I have the honor to transmit herewith, for presentation to the Legislative Assembly, the Fourth Report of the Bureau of Mines.

I have the honor to be, Sir,

Your obedient servant,

A. S. HARDY,
Commissioner of Crown Lands.

DEPARTMENT OF CROWN LANDS,
Toronto, April 9, 1895.

FOURTH REPORT OF

THE BUREAU OF MINES.

To the Honorable ARTHUR S. HARDY,
Commissioner of Crown Lands:

SIR,—I have the honor to submit herewith, for presentation to His Honor the Lieutenant-Governor, the Fourth Report of the Bureau of Mines.

State of the mining industry.

The statistics of the sale and lease of mineral lands, as well as those of the production of ores and other minerals, indicate a condition of inactivity in the mining industry of the province which is no doubt a consequence of the depression in business and inertness of speculation so noticeable in other countries, but especially in Great Britain and the United States, where mining enterprise has heretofore been so brisk. Signs of revival however are beginning to appear in those countries, and increased attention is likely to be given to mining operations here as well as elsewhere.

Gold fields of the province.

The gold fields of the province are attracting greater notice, and during the past year the Rainy Lake region especially drew many explorers and capitalists towards it. Numerous discoveries of gold-bearing ore are reported there, four or five locations are being actively developed, and one gold mill is nearly ready for operation. In the Lake of the Woods district the mine and mill on Sultana island have been worked continuously, and it is claimed that free-milling ore is obtained throughout the entire extent of the workings, now about 200 feet underground. Three other promising properties are in course of development with British, American and Canadian capital, and it is proposed to put a mill on each of them this year. At the present time a mill is in course of erection at Harold lake near the upper waters of the Seine river. The Ophir mine and mill in Galbraith township were operated only during a portion of the year, owing, it is said, to an insufficiency of paid up capital; but the engineer in charge claims that the work done in the mine has proven it to be a good property. The death of one of the principal shareholders, which occurred recently, will doubtless for a time leave the affairs of the company in an unsettled state. The Creighton mine in the township of that name was idle the whole year, but towards the close of it fresh exploratory work was commenced with a diamond drill, and it is reported that a strike of considerable promise has been made; operations to more satisfactorily prove the extent and quality of the ore body are now in progress. In the lake Wahnapitae district a location taken up by Mr. Rinaldo McConnell of Mattawa has attracted much attention by the exceedingly rich samples of ore taken from it. A company has been organized to work the property, and a shaft is in course of being sunk upon the vein. In the Marmora district little has been done. Only one property, the Ledyard mine in Belmont, was worked during the year. Some good ore was raised, and a second-hand Huntington mill was set up, which however gave little or no result. A new Huntington mill has been purchased, and will be running in the course of a few weeks. The gold mill built at Marmora to treat arsenical ores by the Walker-Carter process has been closed down for want of ore to treat.

Geologist and Mineralogist of the Bureau.

Early in the year the staff of the Bureau was strengthened by the appointment of Dr. Arthur P. Coleman, of the School of Practical Science, as Geologist and Mineralogist. Dr. Coleman is required to occupy three of the summer months in geological field work and to make a report thereon, besides other duties of an advisory or special character which do not interfere with his professional functions at the school. Last summer was occupied by him in examining the Rainy Lake gold field, and the belt of country northward of it along the Manitou and Wabigoon waters to the line of the Canadian Pacific Railway. His report and the geological maps accompanying it will be found especially valuable to prospectors in that field. The maps have been prepared in the office of the Director of Surveys. The one of the Rainy Lake district is based upon the map of the Geological Survey accompanying Dr. Andrew C. Lawson's report of 1887-8, with additions showing recent surveys of townships and mining locations from the office maps in the Department, and some corrections in the geological coloring by Dr. Coleman. The map of the Manitou and Wabigoon rivers tract is prepared from Departmental surveys.

Nickel and copper mines.

The nickel and copper mines in the Sudbury region have been actively worked during the year, and as the statistics show the production of matte was much larger than in either of the preceding two years. It is gratifying to know that the severe tests to which nickel-steel armor plate has been subjected continue to show its superiority to all other kinds of plate. Development work was carried on at the Point Mamainse copper locations on lake Superior for the greater part of the year, and as a result of the extent and richness of the finds of ore it is expected that substantial mining operations will be undertaken this year.

Northern Ontario.

The growing interest taken in our northern Ontario, both as a field for settlement and mining enterprise, required that all the trustworthy information relating to it in many volumes of official reports and elsewhere should be searched out and presented in suitable form. This work has been undertaken by the Secretary of the Bureau, Mr. T. W. Gibson, and the valuable paper on The Hinterland of Ontario is the result of his labors.

Diamond drill exploration.

The diamond drill purchased by the Government last year and placed in charge of the Bureau has been steadily employed since the time that it passed the customs in exploring an iron ore property in the county of Frontenac. Information as to the steps taken to select and purchase the drill and the work done with it is presented in the report. There are sanguine hopes, it may be added, that the iron industry will assume active form in the province this year.

Summer Mining Schools.

At the last session of the Legislature provision was made for Summer Mining Schools at Sudbury and Rat Portage, at which practical instruction might be given for the benefit of miners, prospectors and others employed or interested in mining pursuits. Classes were opened at Sudbury, Copper Cliff and Rat Portage, with an aggregate regular attendance of fifty-one. The report of the instructors in charge shows the scope and character of the work undertaken, and the favor with which the project has been received.

Inspector's report.

The Annual Report of the Inspector of Mines accompanies the Report of the Bureau. It gives details of the progress of operations at each of the mines visited by him, and of their condition as regards the safety and health of miners.

I have the honor to be, Sir,
Your obedient servant,

ARCHIBALD BLUE,
Director.

Office of the
Bureau of Mines,
Toronto, April 9, 1895.

SECTION I.

GENERAL INTRODUCTION.

The mineral industry in Ontario affected by

It is never quite safe to say in a Government report that there is a condition of trade stringency in this country, since, theories of trade and commerce having become mixed up with the principles of party politics, a statement of fact upon the subject is apt to be construed as a reflection upon the policy with which the fact is not in accord. But it may be permissible to say that there is business depression outside our own country, the existence and gravity of which the whole world has been obliged to recognize, and that nowhere have its effects been more keenly felt during the last three years than among our neighbors in the United States. This being admitted, and it being known also that the men who have been readiest to invest in mining enterprise here, either in the purchase of mineral lands or in opening and working mines, are foreigners, and chiefly citizens of the United States, the slow rate of progress to be noted in the mineral industry of Ontario will be accounted for sufficiently without the necessity of an assertion on the state of trade in Canada for the men of any political party to differ from or quarrel over. Men who find it troublesome to get money for their own wants at home, either to carry on the operations in which they may be engaged or to provide for the requirements of the household, are not likely to go abroad in search of speculative ventures. When the commercial storm-drum is hoisted the prudent business man, if he does not keep the shelter of the port, does not embark upon unsafe or unknown waters. He waits for the coming of fairer weather; and that is the conduct of many Americans who have been exploiting Ontario as a promising field of mining enterprise. There is abundant evidence of the shrinkage of business in their own country, two or three illustrations of which may be given. In foreign trade the exports in the calendar year 1894 were less than in 1893 by $50,864,484, and the imports were less by $93,567,306. The production of pig iron, which was 6,657,388 tons in 1894, was less by 467,114 tons than in 1893, and less by 2,499,612 tons than in 1892. Then as measured by transactions in the New York mining stock market, there is proof of well nigh fatal collapse. In 1888 the number of shares sold in that market was 11,689,388; in 1889, 4,114,480; in 1890, 3,925,926; in 1891, 2,522,660; in 1892, 1,527,371; in 1893, 624,617; and in 1894, 350,000. But in this case the decline in business was no doubt due in part to a withdrawal of confidence from the market scheme itself. In London, Eng., the volume of new issues of stocks and bonds last year was larger than in any year since 1892, yet nearly one-half of it is to be credited to the last three months of the year. Of the total amount, £91,835,000, only £5,018,000 was invested in mining and land

trade depression in the United States

and Great Britain.

companies, two-thirds of which went to the new gold and land companies in Western Australia. In the foreign trade of the United Kingdom too there was an increase in the calendar year 1894, the total value of imports and exports being £624,699,957, as against £622,783,043 in 1893. The number of persons employed in and about all the mines during the year was 739,097, being 20,350 more than in 1893, the production of pig iron was 534,904 tons more than in 1893, and the amount of coal raised exceeded by 2,798,399 tons the highest output hitherto recorded, viz., that of 1891. The receipts into the exchequer from April 1, 1894, to March 16, 1895, were £96,835,332, as against £93,700,896 for the corresponding period of the previous fiscal year, and this is also a hopeful sign of the revival. In the United States the condition of the iron trade is a good barometric index of business affairs, and for several months that trade has been steadily improving. In 1892 the production of pig iron in the last six months was 48 per cent. of the whole year's output; in 1893 it was 36 per cent.; and in 1894 it was nearly 60 per cent. The first three months of the current year continue to show a steady improvement, and therefore it may be hoped that better times for American industries and capital are near at hand, the reflex influence of which will soon no doubt be felt in our country, for it is certain that never before were the opportunities for mining enterprise in Ontario so well known to Americans as they are now. But it will be asked why, if the chances are so good and if there is so little business depression felt in Canada, Canadians themselves are not eager to invest? It is easier to ask the question than to answer it. Money in large quantities is known to be lying in the banks. The statement for the month ending 28th February ultimo shows that there was deposited in the banks of Canada by the public payable on demand $64,555,403, and payable after notice $115,083,710, making a total of $179,639,113. The statement for the corresponding date in 1881 showed that there was at that time deposited and payable on demand $40,474,518, and payable after notice $38,545,406, being a total of $79,019,924. This was a period of high water mark in commercial and industrial activity in Canada, and men with money were encouraged to invest in business enterprise rather than deposit in the banks at a low rate of interest or at no rate at all. After fourteen years the deposits are seen to have been increased by over $100,000,000, one-third of the whole amount being at call and the rest at a rate of interest possibly not half as much as was allowed in 1881. Yet with all that money in Canadian banks at the credit of Canadians, if $10,000 or $100,000 is required to develop a promising mineral property—the investment of which would be of course a risk—we must look to the United States or Great Britain for it! The labor of the miner alone may develop the mineral wealth of Ontario, as it has done elsewhere upon rare occasions; but the progress of unaided labor in this department of industry must be slow and precarious. With the help of capital the chance of successful effort may be greatly improved, and it does seem to be a deplorable situation that where nature has been so bountiful the citizen folds his arms and the enterprising foreigner is invited to step in to win and carry away the treasure. When the gas fields of Essex and Welland were opened, pipe lines were laid down to convey

Signs of revival.

Why Canadians do not invest.

Capital lying idle in the banks.

cheap fuel to Detroit and Buffalo. But this, fortunately, is an extreme instance of how mineral fortunes may be given away. To be inspired with confidence in the resources of the country is laudable if the facts warrant it; yet more important is the enterprise which undertakes to develop resources when they are discovered and can be utilized. "The most superficial glance at the present condition of Europe," Alexander von Humboldt wrote fifty years ago, "shows that a diminution, or even a total annihilation of national prosperity, must be the award of those states who shrink with slothful indifference from the great struggle of rival nations in the career of the industrial arts." And again: "Those states which take no active part in the general industrial movement, in the choice and preparation of natural substances, or in the application of mechanics and chemistry, and among whom this activity is not appreciated by all classes of society, will infallibly see their prosperity diminish in proportion as neighboring countries become strengthened and invigorated under the genial influence of arts and sciences."[1] The same idea is elaborated by an able writer of our own day, Benjamin Kidd, in dealing with the results of British methods and enterprise in Egypt and India, which he regards as object lessons that will not be without their effect on the minds of the European races. "It will probably be made clear," Mr. Kidd says, "and that at no distant date, that the last thing our civilization is likely to permanently tolerate is the wasting of the resources of the richest regions of the earth through the lack of the elementary qualities of social efficiency in the races possessing them. The right of those races to remain in possession will be recognized; but it will be no part of the future conditions of such recognition that they shall be allowed to prevent the utilization of the immense natural resources which they have in charge. At no remote date, with the means at the disposal of our civilization, the development of these resources must become one of the most pressing and vital questions engaging the attention of the Western races."[2] This is not a new thing in policy or practice; it is as old as the law that "to him that hath shall be given;" yet the achievements of British administration and enterprise in India and Egypt are illustrations which will not fail of influence elsewhere—not impossibly even in Ontario, if her own citizens neglect or miss their opportunities. In the matter of mineral possessions especially what we require is, first the enterprise to prove by substantial prospecting work that a location has mineral value, and secondly a sufficiency of capital to develop and operate it in a business-like way for profit. These are risks that must be taken before the mineral wealth of our country can be utilized. There is no other way. The real estate miner, who buys and sells mineral lands without expending a dollar in labor to show what they are worth, may have his uses; but he does nothing to convert natural resources into tangible wealth. Unemployed money in the bank or the safe, and ores of gold, nickel, copper or iron in the earth, are in that form alike useless to the service of man. The money must go into circulation, and the ores must be won and their metals made ready for the purposes of commerce and the arts.

Consequences of the lack of enterprise.

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[1] Cosmos, vol. I, p. 51. [2] Social Evolution, p. 347.

SALE AND LEASE OF MINERAL LANDS.

The number of patents issued for mineral lands last year, with area and purchase price paid to the treasurer of the province, are given by districts in the following table :

Mining lands patented.

Districts.	No. of patents.	Acres.	$
Rainy River	29	1,703	3,928 00
Thunder Bay	4	909	1,817 00
Algoma	5	551	1,740 00
Elsewhere	2	108	161 00
Totals	40	3,271	7,646 00

In 1893 the number of locations sold was 63, having an area of 4,370 acres and realizing $11,498 ; in 1892 there were 65 locations sold, the area of which was 6,200 acres, and the price paid $15,273 ; while in 1891 the sales numbered 289, having a total area of 59,389 acres, for which $117,514 was paid. In the last year however was included a number of sales of locations carried out as to price under the terms of the old Act. Nearly all sales of 1894 were made at the reduced prices of the amending Act, which are fifty cents per acre less than prices under The Mines Act 1892, and the average price was $2.34 per acre against an average of $2.53 for the two preceding years.

The statistics of leased locations are given in the next table :

Mining lands leased.

Districts.	No. of leases.	Acres.	$
Rainy River	48	5,268¾	5,268 75
Algoma	4	298¾	278 75
Nipissing	9	360	285 38
Elsewhere	5	1,123	655 90
Totals	66	7,050½	6,488 78

In 1893 the number of leases issued was 122, embracing 13,046¾ acres, for which the first year's rental was $11,933.90 In 1892 there were leased 95 locations, with an area of 13,122½ acres, upon which was paid for the first year's rent charge $12,314.36. In 1891, 47 locations with an area of 4,998 acres were leased, and the rent charge paid was $4,886. The only item in the transactions of 1894 which exceeded those of previous years was the amount of rentals received on leases granted in previous years, which under favorable circumstances may be counted upon to show a steady increase. The sum received from this source last year was $3,807.78, as against $2,735.86 in 1893 and $603 in 1892, the leasing system having been introduced in 1891.

The following table presents a statement of transactions in mineral lands for the four years 1891-94 :

Comparative statistics.

—	1894.	1893.	1892.	1891.
No. of locations sold	40	63	65	289
Area of locations sold ......acres	3,271	4,370	6,200	59,389
Price of locations sold ....$	7,646 00	11,489.00	15,273.00	117,514.00
No. of locations leased..........	66	122	95	47
Area of locations leased ....acres	7,050½	13,046¾	13,122½	4,998
Rental of locations leased[3] .....$	10,296.56	14,669.76	12,917.36	4,886.00
Total number of locations......	106	185	160	336
Total area of locations ....acres	10,321½	17,416¾	19,322½	64,387
Total revenue from locations...$	17,942.56	26,158.76	28,190.36	122,400.00

The total number of mining locations sold and leased during the four years was 787, with an area of 111,447¾ acres, for which there has been paid into the treasury of the province $194,691.68. The transactions for the first year were abnormal, because many claims under the old Act had been held over for settlement ; while those of last year owe their decrease to the serious depression in business, resulting in the almost total collapse of speculation throughout the continent.

SUMMARY OF MINERAL PRODUCTION.

Quantity and value of mineral production in 1894, with number of workmen employed and amount of wages paid for labor.

Product.	Quantity.	Value.	Employés.	Wages.
		$		$
Dimension stone......cubic feet	1,340,000	360,470	854	336,700
Heads and sills .... "	47,070	15,900		
Coursing stone ....square yards	22,000	36,000		
Rubble, etc.........cubic yards	223,000	142,000		
Sand and gravel ... "	733,500	203,450	175	61,650
Natural rock cement ....barrels	55,323	48,774	63	13,020
Portland cement .... "	30,580	61,060	105	31,858
Lime....... ....bushels	2,150,000	280,000	575	108,000
Drain tile . ...number	25,000,000	280,000	2,375	388,000
Common brick..... .... "	131,500,000	690,000		
Pressed brick, plain..... "	22,460,000	198,510	209	95,400
Pressed brick, fancy .... "	2,896,000	34,160		
Roofing tile .... "	100,000	1,200		
Terra cotta....................	....	52,360		
Sewer pipe	....	207,000	56	23,000
Pottery	....	134,000	160	47,000
Gypsum..... ...(tons 2,000 lb.)	3,253	9,760	36	9,500
Calcined plaster, etc. "	1,442	22,697		
Salt .... "	35,215	115,551	135	43,350
Nickel........... "	2,570½	612,724	655	311,719
Copper .... "	2,748	195,750		
Cobalt .... "	3¼	1,500		
Gold ....oz....	2,022½	32,776	92	38,032
Petroleum .....imperial gallons	34,912,360	....	....	....
Illuminating oil.. "	14,349,472	1,337,040	486	279,930
Lubricating oil... "	3,817,181	242,688		
All other oils..... "	10,632,141	343,416		
Paraffin wax...........lb....	2,754,300	152,467		
Fuel product	....	71,826		
Natural gas........M cubic feet	1,653,500	204,179	99	53,130
Totals............... 1894	....	6,086,758	6,075	1,840,289
1893	....	6,120,753	7,162	1,935,590

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[3] Including rentals from lands leased in previous years.

BUILDING STONE, SAND AND GRAVEL.

The production of building stone has been steadily falling during the last four years, although the number of working quarries has remained nearly the same. The following table gives the number of quarries, value of product and amount of wages paid for labor for each of the years 1891-94 :

Production in the four years, 1891-94.

Year.	No.	Value.	Wages.
		$	$
1891	84	1,000,000	520,000
1892	100	880,000	730,000
1893	110[4]	721,000	464,000
1894	96	554,370	336,700

In the larger cities of the province, and doubtless also in the towns and villages, building operations have been very slack during the last three years, which fully accounts for the lessening output. It will be observed that the amount paid for wages in 1892 is much larger than in the other years proportionately to the value of product, and in that year the quantity of dimension stone was also much larger than in the other years ; but the difference is more likely to be due to some defect in the returns. When statistics for a number of years have been collected it will be possible to procure averages which can be used to detect and eliminate errors of this sort, the result of oversight or carelessness in filling out the schedules.

Sand and gravel.

Returns of sand and gravel have been obtained for the first time this year. The largest operations are in the Niagara district, near Queenston and on the shore of lake Erie, where building sand of fine quality is obtained, the principal market for which is Buffalo. The total value of output was $203,450, and the industry employed the labor of 175 men.

In the stone quarries the number of employés in 1893 was double the number in 1894, but from the amount of their earnings it is obvious that they worked a much shorter time in the former than in the latter year.

LIME AND CLAY.

Raw material of important industries.

The two most abundant minerals in this country are lime and clay, and they are likewise among the most useful. They furnish the raw material too for mineral industries of the first importance, in which a large amount of capital and many laborers are employed. Yet in the vulgar opinion lime and clay are not worthy of being called minerals, and the seekers after gold, silver, copper, nickel and iron would scorn to recognize the workers in them as fellow-miners. It will not be hard to show however that these very common minerals possess a value not in any degree inferior to the metals, and that they are deserving of much greater attention than they have yet received in this country at the hands of moneyed men and men of the best technical training in the mineral industries.

As to the extent and growth of the industries, information is afforded by the census reports of the Dominion Government. But for comparative records we can only go back to 1881 ; no account was taken of cements in the censuses preceding the one for that year, and the earlier statistics of the brick industry are of little use in showing its growth.

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[4] The report for 1893 (p. 6) gives the number of quarries as 310, instead of 110.

The statistics of the two industries in Canada and the province of Ontario respectively are given in the following table for the census years 1880 and 1890 :

Comparative statistics for 1880 and 1890.

Articles.	Canada.		Ontario.	
	1880.	1890.	1880.	1890.
Lime—				
No. establishments....	1,274	1,184	515	508
Hands employed......	2,537	2,575	1,133	1,005
Wages paid ....$	203,631	465,974	100,200	155,520
Value of product... $	707,132	1,444,453	294,724	478,530
Cement—				
No. establishments ...	9	19	3	12
Hands employed	115	243	29	128
Wages paid ....$	38,151	85,960	7,000	39,245
Value of product....$	91,658	251,175	29,200	153,400
Brick and tile—				
No. establishments....	560	697	400	463
Hands employed.....	4,129	6,737	2,768	3,791
Wages paid . ...$	608,690	1,428,489	405,311	797,257
Value of product....$	1,541,892	3,584,713	971,158	2,154,152

Growth of lime and clay manufacture in Canada, and Ontario's share in it.

The noticeable feature in these statistics is the large share Ontario claims in the progress of the ten years. Ten new cement establishments were added, and all but one are credited to Ontario. The number of hands employed by the industry increased by 128, and all but 29 have been added in Ontario works. The amount paid for wages was greater in 1890 than in 1880 by $47,809, and two-thirds of it was earned in Ontario. The increase in the value of product was $159,517, and three-fourths of it belonged to Ontario. The progress of our province in the manufacture of brick and tile was less conspicuous in the decade, although in number of works, employés, wages and value of output, she exceeds all the other provinces combined. In the increase of works from 1880 to 1890 her share was 63 out of 137 ; of workmen employed it was 1,023 out of 2,608; of wages paid for labor it was $391,946 out of $819,799, and of value of articles produced it was $1,182,994 out of $2,042,821. In the lime industry the number of establishments and of hands employed was almost stationary, both in Ontario and the Dominion, but the increase in wages paid for labor and value of product may seem to be surprisingly large. Possibly the lime-kilns had a much longer run in 1890 than in 1880, seeing that in the Dominion the increase in wages paid was 128 per cent. and in Ontario 194 per cent. In value of product the increase in the Dominion was 104 per cent. and in Ontario 207 per cent.

Assuming the absolute accuracy of the figures, there is another aspect of them which arrests attention, viz., the relativity of the cost of labor to the value of product in Ontario and the other provinces. For the whole Dominion in 1880 the ratio of labor to product in the three industries was 1 : 2.74, and in 1890 it was 1 : 2.67—a proportion which everyone would be disposed to accept as likely. For Ontario however the ratios of labor to product were 1 : 2.52 and 1 . 2.81 for the former and latter years respectively, while for the other provinces they were 1 : 3.06 and 1 : 2.53. The use of improved machinery would account for this disparity to some extent, although not wholly. So also would fluctuations in the price or the efficiency of labor. The latter cause can be dismissed as improbable, in view of the proximity of the provinces; and as regards the former it would, in view of all the circumstances, be fatuous to claim for it more than a very modest share of potency in the radical disturbance of ratios. The real cause will probably be found in the different scales of values adopted in different parts of the country, and it is to be regretted that in the census enumerations account was not taken of quantity as well as of value.

The following table gives the quantity and value of the lime and clay products of the province for the four years 1891-4, as collected by the Bureau, together with the amount of wages paid for labor in each industry:

Lime and clay manufactures in Ontario in the four years 1891-4.

Articles.	1891.	1892.	1893.	1894.
Lime—				
Bushels	2,350,000	2,600,000	2,700,000	2,150,000
Value $	300,000	350,000	364,000	280,000
Wages $	116,000	120,000	122,500	108,000
Natural rock cement—				
Barrels	46,178	54,155	74,153	55,323
Value $	18,318	38,580	63,567	48,774
Wages[5] $	......	....	....	13,020
Portland cement—				
Barrels	2,033	20,247	31,924	30,580
Value $	5,082	47,417	63,848	61,060
Wages[5] $	....	....	....	31,858
Common brick and drain tile—				
Number	167,500,000	185,000,000	179,650,000	156,500,000
Value $	1,040,000	1,080,000	1,122,500	970,000
Wages $	432,000	445,000	451,000	388,000
Pressed brick, roofing tile, etc.—				
Number	13,617,909	22,048,000	21,634,000	25,456,000
Value $	156,699	259,335	217,373	286,230
Wages $	58,000	88,865	80,686	95,400
Sewer pipe—				
Value $	270,000	.......[6]	230,000	207,000
Wages $	38,000	....	34,000	23,000
Pottery—				
Value $	45,000	80,000	115,000	134,000
Wages $	....	25,000	36,000	47,000

In the statistics collected by the Bureau, value of product and wages paid for labor are for each year less than those of the census for 1890. The manufacturers of cement in Ontario gave the value of their product in 1894 as $109,834, while the number of workmen they employed was 168, and the amount of wages paid for labor $44,878. Their product included 55,323 barrels of natural rock and 30,580 barrels of Portland cement. In 1890 there was no Portland cement made in our province; yet the value of cement manufactured that year according to the census was greater than last year by $43,566, while the number of workmen employed was less by 40, and the wages paid for labor less by $5,633. Had we the output for the census year in quantity, the cause of the discrepancy would more clearly appear. The Bureau's returns of brick and tile for 1894 are also much lower in value than those of the census for 1890, but this is no doubt due to the fact that the financial stringency of last year caused many works to close down early in the season, while others were idle the whole year. The following table shows the value of lime and clay products for each of the last four years according to the Bureau's returns, with the amount of wages paid for labor, and also the value of all mineral products of the province and the wages paid for labor in the same years:

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[5] In the returns for 1891-3 wages for natural rock and Portland cements are not given separately. For both kinds of cement the wages paid for labor were $23,400 in 1891, $53,151 in 1892 and $60,208 in 1893.

[6] No statistics of sewer pipe received for 1892.

Articles.	1891.	1892.	1893.	1894.
Lime and cements—				
Value ....$	320,441	435,997	491,415	389,834
Wages ....$	139,400	173,151	182,708	152,878
Clay products—				
Value ....$	1,511,699	1,419,335	1,684,873	1,597,230
Wages ....$	528,000	558,865	601,686	553,400
Totals, lime, cements and clay—				
Value ....$	1,832,140	1,855,332	2,176,288	1,987,064
Wages ....$	667,400	732,016	784,394	706,278
Mineral products of the province—				
Value ....$	4,705,673	5,374,139	6,120,753	6,086,758
Wages ....$	1,659,141[7]	2,591,344	1,935,590	1,840.289

Imports of cement.

It has been shown that on the basis of values the manufacture of cement in Canada increased from $91,658 in 1880 to $251,175 in 1890. The whole of this product was consumed in the country, but it was far from supplying our needs. In the fiscal year 1880-1 we imported hydraulic Roman and Portland cements to the value of $53,765, and in 1890-1 to the value of $323,690. But since the fiscal year 1886-7 the Trade Tables give us the quantity as well as the value of cements imported, and they show that the demand has been largely on the increase. The following table gives our imports of Portland and Roman cements for each of the seven fiscal years 1886-93, the great bulk of which was the Portland variety:

Year.	Barrels.	Value.
1886-7	102,750	$148,054
1887-8	122,402	177,158
1888-9	122,273	179,406
1889-90	192,322	313,572
1890-1	183,728	304,648
1891-2	187,233	281,553
1892-3	229,492	316,179
1893-4	234,231	284,964

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[7] Not including wages paid in the petroleum, pottery and salt industries this year.

The total importation in the eight years was 1,374,431 barrels, valued in the Trade Tables at $2,005,534 ; but to this should be added the $546,435 of customs dues paid to the Government, the costs of freight and insurance and the profits of importers, in reckoning the price paid by the consumers—an aggregate of not less than $3,750,000. In these eight years the increase in quantity was 128 per cent., and in value 92 per cent. But a more striking evidence of the growing demand is afforded by a comparison of the imports of Portland and Roman cements for 1880-81 and 1892-93. In the former year their value was only $45,646, and in the latter it was $284,964, being an increase of nearly 525 per cent. in 12 years. This is a rate that perhaps has not been equalled in any other article of Canadian importation. What is the secret of it, and is the demand likely to be maintained ?

Prospect of an increased consumption of cement.

The answer to these questions may be summed up in a significant term of very modern usage on this continent, viz., good roads. The setting in of the era of good roads in this country, as well as in the United States, does not date back ten years, but in that short period much has been learned on the subject, and the street engineer is now as much of a specialist and quite as useful in his way as the military engineer or the mining engineer. The Roman roads of Europe, which have lasted out the traffic of two thousand years, have taught him the invaluable lesson that the only sure way to make a good road is to lay a good and strong foundation. But instead of using stone material, as the Romans did in constructing their great military roads, he has adopted the concrete used by them in the construction of temples and other public buildings, some of whose walls have been standing 2,400 years. The great dome built by Agrippa, the friend of Augustus, "the immortal monument of the Pantheon," as Gibbon described it—now the church of Santa Maria della Rotonda—is an edifice in concrete, and though ravaged by fire and assaulted by the Huns and Goths, it is still intact after more than 1,900 years. Concrete is the street engineer's material for street building, and his chief reliance in the making of it is not Roman or any other kind of natural cement, but the stronger and more durable Portland. In Toronto during the last five years not less than 150,000 barrels of cement have been used in making concrete for street construction, and of this quantity Mr. Rust tells me that not more than 4,000 barrels have been the native hydraulic cement. "Up to the last year or two," he says, "it was all imported Portland cement from Europe." In other towns and cities of the Dominion cement is also being used in steadily increasing quantities in building sewers and streets, and the results are so uniformly good that the material promises to grow steadily in favor. It is almost certain then that for many years yet to come the demand for Portland cement will continue as experience proves the utility and permanency of the concrete roadbed.

But why should we remain dependent on foreign sources of supply for Portland cement ? We have in Ontario abundance of raw material for producing it. In scores of localities beds of white shell marl of large extent and excellent quality are found, some of them at the bottom of lakes in which myriads of fresh water shells yet survive, to add to the thickness of the deposit as one generation follows another, and others of them on the sites of lakes long ago filled up with peaty mould or drained by continental elevations. This marl, if unmixed with sand, clay, peat, or other matter of mineral or vegetable origin, is almost pure carbonate of lime, and furnishes the principal material for the manufacture of Portland cement. The necessary proportion of clay is a matter of experiment, but in all cases the purer and more uniform the quality of the marl, the easier it is to get a right mixture.

Quality of Portland cement produced in Ontario.

Our manufacturers in Ontario have acquired their experience slowly and dearly. Mr. Rathbun told me that it cost him five years of testing, with the aid of a chemist, before he was convinced that it would be safe to start his works. Mr. Butchart also told me that it cost his company several thousands of dollars, a visit to some of the best Portland cement works in England—where he was admitted as a special favor—and the service of two experts in the construction of a suitable plant, before they could produce a commercial article. But the Rathbun Company and the Owen Sound Company have succeeded, and during the last three years they have been producing a Portland cement which satisfies every requirement.

Mr. C. H. Rust, deputy city engineer of Toronto, makes this statement concerning it, in a letter which I have received from him :

"Since 1892 we have used a quantity of Portland cement made by the Rathbun Company at Napanee mills, and by the Owen Sound Company at Shallow Lake. Both these brands are quite equal to the majority of the imported cements, and no doubt when their facilities for manufacturing are increased nearly all the cement used in this city will be of home manufacture."

The Owen Sound Company had the misfortune last summer to lose its mill by fire, but a new one has been erected in its stead. The company has a large supply of raw material alongside of the works, suitable clay for mixing being found immediately below the marl, and doubtless the capacity of the new mill has been designed to meet the growing requirements of the trade.

The only other Portland cement works in the province are at Marlbank in the county of Hastings. The site was chosen because of its nearness to a very large deposit of marl; but although English capital was put into the business, and presumably English experience also, the enterprise had to pass through the usual ordeal of disappointment and delay before a successful beginning was made.

The output of those three mills last year was 30,580 barrels, but one of them was burnt down early in the season, and another worked only part time. Had their capacity been eight times as great they could barely have supplied the quantity of Portland cement imported by Canada during the fiscal year 1893-4, and obviously therefore there is ample room for the home manufacture to grow. With raw material so abundant and accessible, and with capital seeking new channels of investment, and labor seeking employment, why should we not produce in the country all the Portland cement that our market requires? An article of uniform quality will always be in request by customers, and with care on the part of the manufacturer there is no reason why he should not be successful in supplying a distinct brand. But as long as we are dependent on foreign makers we cannot hope to be supplied with cement of uniform quality, for when large orders have to be filled it is the common practice of even large mill owners to buy lots from other manufacturers and so make a prompt shipment. The result is that there are as many brands as makers, and with cements of different qualities, some quick-setting and some slow-setting, it is hardly possible to make a first-rate concrete. This is a risk which may easily be avoided if orders are placed at home, with the home manufacturer, and the good results obtained from our Ontario cements are no doubt due to the fact that orders are honestly made up, each manufacturer being jealous of his own reputation.

Growth of clay products.

As regards the products of clay, it is not necessary that much should be said. Taking the various articles of common and pressed bricks, terra cotta, tile, sewer pipe and pottery, the number of men employed in their manufacture in Ontario last year was 2,800, with earnings of $553,400. The aggregate value of their products was $1,597,230, or more than one-fourth of all the mineral production of the province in the same year. This fact alone suffices to prove the importance of our clay industries; yet it is obvious that they are capable of greater development. The manufacture of pressed brick and terra cotta began here only six years ago, and last year, in spite of the collapse in the building trade, the value of the output of six works was $286,230. It gave employment to 209 workmen and paid them wages to the amount of $95,400. The improvement already noticeable in the architecture of our cities as a consequence of the use of pressed brick and terra cotta is bringing this material fast into favor, and it may be said that the earth affords no better building material than a properly burnt brick, and none which so readily lends itself to the production of handsome architectural effects. In the strong and fine-textured shales of our Hudson River and Medina formations, conveniently situated and easily quarried, Ontario is favored above most provinces and states in America.

Pressed brick and terra cotta.

The same shales are also found to be suitable for the manufacture of sewer pipe, with proper mixtures, and last year the output of two establishments employed in this industry was $207,000, employing 56 workmen, and paying wages to the amount of $23,000.

Vitrified brick.

Another clay industry is now on the eve of commencement, and if successfully established it promises to be a great boon to our towns and cities, viz., the manufacture of vitrified brick for street paving. In Ohio, Illinois, Iowa and other American states this has now grown to be a very important industry, and it is supplying a material for street construction which on all points of merit is not equalled by any other hitherto employed for the purpose. Many mistakes were committed by the first makers of paving brick, and there is much yet to be learned as to the clays or clay mixtures which give the best results, as well as to the proper degree and duration of heat to produce a hard, tough and impervious brick. But much is already known, and with careful experiments and close observation many works are enabled to produce with regularity a high percentage of paving brick of uniform quality from every charge of a kiln. A number of experiments have recently been made in Toronto, Hamilton and elsewhere in this province, and although each expert will assure you that he alone knows the secret, and that no one else has the clays for a right mixture but himself, you may rest assured that in a matter of this sort the key and the ward are not so hard to match as the tribe of experts would have you believe. In several instances encouraging progress has been made, especially with the Medina and Hudson River shales.

We may therefore, I think, look with confidence to an early beginning of the production of paving brick in Ontario; and when that time comes we shall be no longer at the mercy of trust concerns like the owners of Pitch Lake asphalt, as illustrated last summer in the case of a contract for paving in the city of Hamilton. When we are producing Portland cement from our own shell marls and clays to the full extent in which it is required for street concrete, and paving brick from our own shales to cover the concrete, we shall be as independent as we ought to be in supplying ourselves with the materials of such everyday requirements as are called for in the building of good roads. In so doing also we shall be utilizing our raw materials of clay and lime, otherwise of no value, finding profitable investment for capital lying idle in the banks, and giving employment to hundreds if not thousands of men who for lack of work to do are finding it hard to win their daily bread.

Importance of accurate experiments.

Reference has been made to the experiments conducted by the manufacturers of brick and cement, preliminary to the building of works to commence production on a commercial scale. These experiments demand patience, exactness and scientific method, as well as the use of costly appliances. Why should they not be taken up in our technical schools, where there are professors having the necessary expert knowledge and training, and the appliances for making tests and ascertaining results with unerring accuracy? The importance of the clay industry has been so well recognized by the Legislature of Ohio that a course of practical and scientific instruction in the art of clay-making and ceramics has been added to the educational work of the state University, and the first term of this department opened in September of last year. Work of that character is as much needed in Ontario as in Ohio, and the professors of our scientific schools cannot too soon prepare to enter upon it.

GYPSUM AND SALT.

Gypsum areas in the Grand River valley.

Gypsum and salt, though entirely different in their chemical composition, are characteristic minerals of the Onondaga formation, which extends over a large area of western Ontario.

In the lower basin of the Grand river, from Paris to Cayuga, beds of gypsum occur in isolated areas. Several have been worked for more than fifty years, and although the gypsum industry has never been an important one, it has managed to exist, and at the present time the yearly value of products is perhaps greater than ever before. This is wholly due however to the new uses found for it in the manufacture of alabastine and a material for destroying the voracious potato bug. Increased quantities are also used in the production of calcined plaster. As a fertilizer ground plaster will not bear long transportation, and the market for it is limited to the district in which it is produced.

The salt area of western Ontario.

The salt area was at first supposed to be confined to portions of the counties of Huron and Bruce, but borings made during recent years have shown that it extends into parts of Middlesex, Lambton, Essex and Kent. It appears likely indeed that the thickest beds are in the last named county, but they are at a much greater depth than elsewhere. A well bored two years ago at Windsor, county of Essex, struck a very good deposit, and a large quantity of salt was produced last year at the works erected there. In Huron and Bruce for some cause the industry was less active than in former years, and the total product of the province was less than in any year since 1891. In the latter year the product was 44,167 tons, valued at $157,000; in 1892 it was 43,387 tons, valued at $162,000 ; in 1893 it was 48,450 tons, valued at $149,850 ; while last year it was only 35,215 tons, valued at $115,551. It may be remarked also that with the decrease in the business there is a corresponding difficulty in procuring returns from the manufacturers.

NICKEL, COPPER AND COBALT.

Operations at Sudbury.

In the Sudbury district last year operations were carried on by five mining companies upon seven locations, and the quantity of ore smelted was larger than in any former year. The statistics for 1890 and 1891 are not available for a full comparison, as they embraced only the quantity and value of ore raised and smelted, and the amount of wages paid for labor. For the three succeeding years the statistics are as follows :

Comparative statistics in 1892-4.

—	1892.	1893.	1894.
Ore raised.................tons	72,349	64,043	112,037
Ore smelted .... "	61,924	63,944	87,916
Ordinary matte............. "	6,278	7,176	10,410
Bessemerized matte......... "	1,880	452	1,470
Nickel contents...... ...... "	2,082	1,653	2,570½
Copper contents .... "	1,936	1,431	2,748
Cobalt contents .... ".	8½	19	3¼
Value of nickel ....$	590,902	454,702	612,724
Value of copper.............."	232,135	115,200	195,750
Value of cobalt ...."	3,713	9,400	1,500
Men employed .... no.	690	495	655
Wages paid ....$	339,821	252,516	311,719

In the Report of the Bureau for 1893 the nickel contents of the matte were given as 1,642 tons instead of 1,653. The error occurred in the returns of one of the companies, and a correction subsequently made was overlooked in compiling the statistics. It may be stated here that the estimates of metallic contents of the matte are computed from the averages of analyses made at the works and entered on the forms returned to the Bureau, as are also the values of metal contents.

The next table gives the quantity of ore raised and smelted for each of the five years 1890-94, and the average per cent. of metallic contents of ore smelted in the three years 1892-4 :

Percentage of metallic contents in ore.

Year.	Ore raised, tons.	Ore smelted, tons.	Per cent. of metallic contents in ore smelted.[8]		
			Nickel.	Copper.	Cobalt.
1890	130,278	59,329	....	....	.....
1891	85,790	71,480	....	....	.....
1892	72,349	61,924	3.36	3.19	.1007
1893	64,043	63,944	2.21	2.38	.0800
1894	112,037	87,916	2.92	3.14	.0721

The total quantity of ore raised in the five years is 464,497 tons, and the total quantity smelted 344,593 tons, from which it appears that there is in stock or in the roast heaps 119,904 tons. For the three years 1892-4 the computed metallic contents of matte product is 6,305½ tons nickel, 6,115 tons copper and 30¾ tons cobalt. At the average rate of these three years the nickel contents of ore smelted in the five years would be 10,165 tons, and the copper contents 9,857 tons. The output of the mines last year was more than in any previous year excepting the first; but the output of the furnaces shows a large increase, being 16,436 tons in excess of 1891, the year in which the United States government made its purchase of 4,536 tons of matte to supply nickel for use in the manufacture of nickel steel for armor plate. The most likely cause of the increase of production is the fall in the price of nickel, which is due largely to improved processes in separating it from the matte.

Valuation of metallic contents of matte.

The total value of nickel, copper and cobalt in the matte, based upon the selling price at the works, was $826,750 in 1892, $579,302 in 1893 and $809,974 in 1894. All the matte produced in the Sudbury district is shipped to the United States or Europe, where it is treated and the several metals extracted from it in the forms required for commercial use. This is the costliest and most difficult part of the process, and of course no account is taken of it in computing the value of the metallic contents here. To compute values on the basis of the market price of refined nickel, copper and cobalt in Europe or the United States would be very misleading. The following table gives the average values per ton and per pound computed at the selling price per unit of metal contents at Sudbury for each of the three years 1892-4 :

Year.	Nickel.		Copper.		Cobalt.	
	per ton.	per lb.	per ton.	per lb.	per ton.	per lb.
	$	cents.	$	cents.	$	cents.
1892	283 81	14.190	119 90	5.995	436 82	21.841
1893	275 08	13.754	80 50	4.025	494 73	24.736
1894	238 36	11.918	71 23	3.561	461 54	23.077

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[8] The ores of only one company contain cobalt, and in 1892 the ores of one company yielded no copper; all the ores carry nickel. Percentages are calculated on the ores containing the several metals, and not on the aggregate quantity of ores.

Comparison of values and market prices.

The statistics of the Bureau are for the year commencing 1st November and ending 31st October. The London, Eng., quotations for this period show that in the year 1892 the price of refined nickel ranged from 2s. sterling in February to 1s. 10d. in July and 1s. 9d. in October, the average being 1s. 11d. In 1893 the average was 1s. 8d., ranging from 1s. 9d. in the first half of the year to 1s. 7½d. in the latter half. In 1894 prices ranged from 1s. 7½d. from October to May and then fell steadily to 1s. 7d. in June, to 1s. 6d. in August, to 1s. 5d. in September, and to 1s. 4d. in October, the average being 1s. 6d. Reduced to our currency, these averages would be 46½ cents per pound in 1892, 40½ cents in 1893 and 36½ cents in 1894; but from 1st November, 1891, to 31st October, 1894, the market price fell from 48½ to 32⅓ cents per pound, or 33⅓ per cent. Prices in the United States have ruled higher nearly by the amount of the customs duties, or from about 56 cents per pound in 1892 to 48 cents in 1893, and to 41 cents in 1894. It will be observed that in comparing average values at Sudbury with average prices in London and New York, there is a discrepancy for 1893, and there is a strong probability that the fault is in the returns made to the Bureau for that year. The average of London prices for copper (good merchantable brand cash) in 1892 was £44 9s. 6d. per ton, in 1893 £43 14s., and in 1894 £40 14s. 5d.; or, in our currency, 9.65 cents per pound in 1892, 9.44 cents in 1893, and 8.83 cents in 1894. Here again there is an obvious disagreement between market price and value, although not of the same character, being one of proportions.

The number and classification of workers employed at the mines during the four years 1891-4 are given in the following table, together with the total amount of their wage-earnings each year:

Comparative statistics of workmen and wages, 1891-4.

Year.	Workers of 15 to 17 years		Workers of over 17 years		Total workers.	Total wages.
	above ground.	under ground.	above ground.	under ground.		
						$
1891..	25	....	439	244	708	322,201
1892..	10	....	483	197	690	339,821
1893..	10	....	356	129	495	252,516
1894..	17	....	395	243	655	311,719

The Mines Act 1892 provides that no boy under the age of fifteen years shall be employed in any mine below ground, and that no boy of fifteen and under seventeen years of age shall be employed in any mine below ground for more than forty-eight hours in any one week, or more than eight hours in any one day. It also provides that no girl or woman shall be employed at mining work, or allowed to be for the purpose of employment at mining work in or about any mine. It will be seen by the foregoing table that only a few boys between the ages of fifteen and seventeen years are employed above ground, and that none are employed below. It will be noticed also that a much larger number of men were employed above ground in 1891 and 1892 than since, no doubt because of the fact that more work of a preliminary nature was required at the opening of the mines. The amount of wages includes as well what was paid to workers at the roast heaps and at the smelting furnaces as to those employed directly at the mines above and below ground; consequently the actual cost of mining the ore cannot be computed. Neither can the labor cost of the quantity of ore smelted or of its matte product, since the whole of the ore raised in any year was not treated in the furnace. In 1893 however the quantity smelted was only 99 tons less than the ore taken from the mines, and for that year the average labor cost of ore when reduced to matte would be $3.95 per ton. For the three years 1892-4 the total wage-earnings at the mines and works was $904,056, and the total value of matte product $2,216,026. Salaries of managers and clerks are not included in wages, and no data are available to show the cost of mining supplies and fuel or the labor saving value of mining machinery and smelting plant.

Processes for cheapening nickel.

Reference has been made to new processes of refining the metallic contents of matte, and especially to the cheapening of nickel as a result of these improvements. An invention of Robert M. Thompson of the Orford Copper Company had a noticeable effect on prices three years ago, and metallurgists since then have not been idle in the search for better methods.

It is a well-known chemical fact that copper in the presence of and in connection with any member of the iron group of metals is not attacked by an acid or acid solution, and that in solution of any copper salt a complete separation of that metal may be obtained by the addition to the solution of metallic iron or any other element of the iron group, such for instance as nickel or cobalt. Upon this principle Messrs. Grant and Richardson, of Toronto, have devised a method for the refining of the copper-nickel mattes of the Sudbury district and obtaining, it is claimed, in a cheap, simple and effectual manner, a complete separation of the two metals, each absolutely free from any trace of the other. This process is especially applicable to the blown or Bessemer mattes, which usually contain but a small percentage of iron, and is described by the inventors as follows:

The Grant-Richardson invention for refining nickel-copper mattes.

"In the first place the matte (which may contain nickel, copper, iron and cobalt) is crushed to a moderate degree of fineness and then roasted to complete oxidation in a reverberatory or other suitable furnace. The resulting mixed oxides are then placed in a suitable receptacle, provided with means whereby the contents may be properly stirred or agitated and there subjected to the action of heat and a suitable reducing gas, such as hydrogen, carbon monoxide, natural gas or water gas, until complete reduction of the metallic oxides has taken place. It is important that this reduction be made, because it helps the process in the subsequent treatment with sulphuric acid as hereafter described. The sulphuric acid will fail to act upon a coarse mixture of the metals so as to obtain a separation of them, but if the oxides are reduced to a finely divided mixture of the metals the action is immediate and very rapid, whereas in the former case the action is exceedingly slow and stops after a certain period, owing to the accumulation of undissolved copper on the surface of the lumps. If much iron is present in the matte it is considered preferable to increase the temperature towards the close of the operation of reduction in order that the resulting metals may not be too strongly pyrophoric. At this stage of the process the matte has been reduced to a finely divided mixture of nickel and copper and a small quantity of iron, if any were present in the matte under treatment. This finely divided mixture is then removed to a suitable tank and there subjected to the action of an acid, preferably diluted sulphuric. By the action of this acid the iron and nickel pass into solution as sulphates, while in the presence of the nickel scarcely any of the copper is attacked. In this operation by keeping the reduced metals in excess with respect to the acid a solution may be obtained absolutely free from copper, but in practice it is preferred to use such a quantity of acid as will fully combine with the whole of the iron and nickel present. In this case the resulting copper slimes are left absolutely free from nickel and iron, while it is found that a small proportion of copper sulphate is present in the resulting solution. To precipitate this, the solution is placed in another tank and there acted upon by a fresh portion of the finely divided metals in order to neutralize any free acid and completely precipitate all traces of copper therein. The solution is then carefully filtered or decanted from the slimes in the tank and subjected to the action of chlorine gas or atmospheric air by passing streams of the same through the solution in order to peroxidize the iron and cobalt if the latter be present. The iron or iron and cobalt may then be precipitated by any of the usual and well known methods. The remaining solution of nickel sulphate may then be used for the preparation of any of the nickel salts, or the nickel may be precipitated as nickel hydroxide by the use of lime and then converted into the oxide or metal. It is preferred however to allow the hot solution to cool and the larger proportion of the nickel sulphate to crystallize out and to use the mother liquor to dilute fresh portions of the acid. The nickel sulphate so obtained is then roasted to oxide in a reverberatory furnace, and the oxide reduced if so desired by any of the usual methods to metallic nickel. It is claimed by this method that a nickel chemically free from any trace of copper may be obtained, a fact of immense importance in the production of ferro-nickel for the manufacture of nickel steel."[9]

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[9] Experiments continue to be made also to simplify and cheapen the process of converting the ore into matte. Mr. James McArthur, general manager of the Canadian Copper Company at Copper Cliff, has been at work for some time in improving a method of his own invention, and the following account of a trial run of fifteen pots of matte he has given me since this report was presented to the Legislature : "The pyritic or green ore smelting trial on Monday the 8th inst. (April), was a nine hours' trial run, of a larger scale test than that of last year, and was simply to determine the present value and future modifications of certain parts of this process, as we have as yet no permanent instalment for its operation. This can only be arrived at by occasional trials from time to time, as opportunity offers, without interfering with the general run of work. But the principle of the process as embodied in my application for patent rights has so far proved its value by trial. It will however take a more lengthy trial to form anything like a correct idea as to costs, wear and tear, repairs, etc. To me the matter of importance is, to provide from the molten bath in the crucible or bessemerizing section of the furnace the requisite hot air for the partial oxidation and smelting of the green ore fed in at the upper section of the furnace. This I arrive at by a constant bessemerizing action on the crucible bath from which the hot and spent air ascends to the green ore in the upper section of the furnace, performing a second duty on the ore charge, making the operation continuous in one furnace and without the use of external hot-blast ovens. But as the ores of this district are not heavy in sulphur, they cannot furnish all the heat required for their own treatment, and the difference is made up with carbonaceous fuels. The furnace is vertical, composed of lower and upper sections. The upper has volume tuyeres and is contracted in width for two feet below this point, while the lower has the regular bessemerizing tuyere. I will not speculate on the extreme probabilities of this as a future process, but await the opportunity for further results by trial."

The process has been patented in Europe and America, and if refined nickel can be produced by it at the low cost estimated by the inventors it will no doubt soon be brought into practical use.

GOLD AND SILVER.

Silver mines closed down.

No work was carried on in the silver mines of the province last year. The low price of silver which closed down so many large mines in the United States two years ago has continued its effect there. Silver indeed fell steadily in price last year, and until the market for it revives none but the richest and best producing mines are likely to be worked. The owners of silver properties in Ontario are therefore not sanguine. Gold mining offers better attractions, but it has not yet reached a business basis in Ontario. A number of properties upon which work was carried on in 1893 remained idle last year for lack of capital or enterprise. Of the four which have made returns only three were metal producing mines, and one of these gave results of only a few days' milling. Another was worked only part of the year owing to financial difficulties ; and there is but one that can rank as a mining enterprise. The following table gives the statistics of gold mining for the three years 1892-4, as fully as they have been furnished :

Progress of gold mining.

—	1892.	1893.	1894.
Mines worked ....no.	9	15	4
Men employed above ground.... "	85	112	40
Men employed under ground ... "	40	56	52
Ore mined ....tons.	3,710	5,560	2,428 [10]
Gold product ....oz.	....	1,695	2,022½
Gold value ....$	36,900 [11]	32,960	32,776
Wages paid ...."	22,750	49,027	38,032

These are not very satisfying figures, but they will no doubt be greatly improved upon in 1895. There is every promise of work being carried on more vigorously, by better methods and at a larger number of works.[12]

PETROLEUM AND NATURAL GAS.

Common origin of petroleum and natural gas.

Petroleum and natural gas are now generally believed to have had a common origin. The latter originates under many conditions in which the former does not appear, Professor Orton says, but petroleum is never found free from inflammable gas, and in a large way all the facts and occurrences of both so exactly correspond that it is impossible to separate them in respect to their origin. Small quantities of oil have been found in the gas fields of Welland and Essex, and an opinion prevails that in Essex there are great storehouses of oil which prospectors are taking means to discover. In Petrolia and Oil Springs every oil well gives off more or less gas, and in the early days of the industry in Lambton the gas flow was very considerable; but in those days no thought was taken of utilizing gas as an article of fuel.

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[10] The returns of ore mined in 1894 are complete only for two of the three producing mines. [11] This value is estimated, as only a small part of the ore was milled.

[12] During the present winter promising development work has been carried on upon locations in the Pine Portage district, a few miles southeast of Rat Portage, under the direction of Mr. Torrance, M.E., of Montreal, and arrangements are being made to put a mill there. The Rainy Lake region was visited last month (March 11-16) by Mr. William Margach, Crown Timber agent at Rat Portage, and he reports prospecting work on a number of locations. "I was at the Wiegand, Hillier, Sterling & Bull and Barclay & Mosher camps on the north shore of Seine river and on Shoal, Wild Potato and Bad Vermilion lakes. At the Wiegand mine there is one shaft down 20 feet and another 25 to 30 feet, from both of which they are taking out rich ore. They are getting out timber and preparing to build a mill. At Hillier's mine a five-stamp mill is completed and they are waiting for warm weather to start it ; there is a large ore pile at this mine. At Sterling & Bull's two shafts have been started, one down 20 and the other 10 feet, with a dozen men at work. J. G. McIntyre of Niagara Falls, N.Y., pulp manufacturer, has bought one location from Mosher & Kelly for $40,000, and one from Mosher, Barclay & Haight for $65,000, paying $5,000 down. I met him there with his expert, and they were quite sanguine. The woods were full of explorers, where the snow has gone on the highlands ; and at a little boarding house at the mouth of the Seine river, 18 by 24 feet, thirty of us found accommodation."

Revival of the petroleum industry.

The petroleum industry has experienced a recent revival by an increase of price which set in during the latter part of last year, but the effect is not noticeable in the returns made to the Bureau. For the current year there will no doubt be improvement, at least in the value of products; for it may be doubted if the fields now worked can be made to yield a larger supply of crude than they have been producing in recent years. It is certain however that promising districts will be tested, and probably one or two abandoned fields will receive attention again. Already enquiries are beginning to be made concerning the supply of petroleum in the region of lake Athabasca, in the Northwest territories, where some test borings have been made under direction of the Geological Survey; and if prices are maintained the enterprise of oil men may be depended on to explore and operate every field within practicable reach. The fuel value of petroleum and its products is now so well established by means of new processes that for this use alone the demand is likely to keep up.

Comparative statistics of production and value of crude.

The following table gives the quantity of crude petroleum produced in the Petrolia and Oil Springs fields for each of the four years 1891-94, and the value of it computed from the average prices for crude:

Year.	Imperial gals.	Value.	Val. per gal.
		$	cents.
1891	31,312,645	1,209,558	3.863
1892	28,000,000	1,000,000	3.571
1893	34,055,000	1,099,868	3.230
1894	34,912,360	1,094,852	3.136

Recent market quotations for crude.

There was a steady decline in average price from 1891 to 1894, and in the latter year quotations fell from $1.01 per imperial barrel in January to 92 cents in May, rising to 93 cents in June and July to 95 in August, and 98 in September, until $1.11¼ was reached in October. Since then the advance has been steady to the present time, averaging $1.12 per barrel in November and $1.15½ in December, $1.16½ in January, $1.20 in February and $1.27 in March, reaching $1.31 at the end of the last month.

Statistics of the refining industry.

The refining industry, which at one time was carried on extensively in London, is now for the most part located at Petrolia. Reports of the quantity and value of the several products of all the refineries have not been obtained for any year, but sufficient statistics have been supplied from which to obtain reliable averages for the three years 1892-94. From these data the following estimates have been computed:

Product.	1892		1893		1894	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Illuminating oil, gal.	10,862,894	$919,315	13,322,320	$1,372,209	14,349,472	$1,337,040
Lubricating oil "	3,457,570	138,304	4,239,847	277,500	3,817,181	242,688
All other oils "	7,654,723	272,577	11,220,705	323,156	10,632,141	343,416
Paraffin wax, lb.	647,950	70,239	2,250,000	143,325	2,754,300	152,467
Fuel product	....	....	....	72,500	....	71,326

The total value of distilled product in 1892 was $1,400,435, in 1893 $2,188,690 and in 1894 $2,146,937. The returns of 1892 did not give the number of workmen employed at the refineries; but in 1893 there were 515, with wage earnings of $302,000, and in 1894 there were 486, with wage earnings of $279,930. The industry gives employment directly and indirectly to many other workmen, at the wells and in the manufacture of plant, machinery, outfits of various kinds, etc., but there are no ready means of obtaining statistics of these.

Percentages of product from the crude.

Evidence of the progress made in the refining of crude oil is shown by the following table, which gives the percentages of the several products except paraffin and fuel material obtained at the refineries in each of the three years:

Product.	1892 p.c. of crude.	1893 p.c. of crude.	1894 p.c. of crude.
Illuminating oil	38.67	39.12	41.10
Lubricating oil	12.85	12.45	10.91
All other oils.....	27.34	28.14	30.45
Totals.......................	78.86	79.71	82.46

The gain in all oils extracted from the crude in 1894 as compared with 1892 is shown to have been 4.10 per cent., and in illuminating oil alone 2.43 per cent. Much progress has also been made during recent years in the quality of illuminating oil, which is now little inferior to the best American, although the crude contains a much higher percentage of sulphur.[13]

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[13] The difficulty of extracting sulphur from Canadian petroleum by a cheap and expeditious process has long beset our refiners, and many experiments have been made to overcome it. The latest of these, known as the McKam process, gives promise however of producing refined oil from the Canadian crude equal in illuminating properties, color and freedom from odor to the best American brands. From the applications which have been made to the Canadian and United States patent offices for letters patent, it appears that there is placed in the still one or more tubes, each having an open end above the level of the charge, and extending in a series of V shapes from one end of the still to the other, with an exit into the condenser. These tubes are filled with coarse or lumpy lime and litharge in dry form, and when the vaporized oil rises to the top of the still and escapes through the tubes into the condenser the sulphur contained in it is taken up and retained by the lime and litharge, for both of which it has a strong affinity. It is claimed that in this way the desulphurization and refining are completed by one process, and that 40 per cent. of pure illuminating oil may be extracted from the crude at less cost than by any system hitherto adopted. If the process will accomplish all that is claimed for it, much will have been done to raise the standard of our illuminating oil and to encourage the oil pumping and refining industries of the province. To facilitate the filling and cleaning out of the tubes, it should be explained, openings are made at the upper and lower angles, with caps to be put on or taken off as may be required; and any common refining still may be fitted up with the improved apparatus.

Natural gas.

Tapping Ontario fields into the United States.

The chief feature of interest to note in connection with natural gas in 1894 is the laying down of a pipe line in the county of Essex to connect the gas field on the shore of lake Erie in that county with the city of Detroit. The total length of this line is about 35 miles, but as it was not completed until December the output does not enter into the statistics of the year. The chief value of the natural gas product of Ontario now is reaped by Detroit and Buffalo, whose citizens enjoy whatever boon this cheap and clean fuel affords. Formerly those cities had drawn supplies of gas from the Ohio and Pennsylvania fields, but these in time became so far depleted that the supplies were cut off. A few years more or less will witness the exhaustion of the Ontario fields also, yet without Ontario profiting to any extent worthy of mention from the utilization of this gift of nature. The following comparative table for the three years 1892-94 shows the extent to which the gas fields of the province have been developed :

Comparative statistics for three years 1892-94.

—	1892.	1893.	1894.
Producing wells, ...no	73	107	110
Gas product ....M cu. ft	....	2,342,000	1,653,500
Value of gas. ....$	160,000	238,200	204,179
Miles gas pipe..................	150	117	183½
Workmen, ...no	....	59	99
Wages for labor.............$	55,000	24,592	53,130

The gas product of the wells for 1892 was not given, and although the number of producing wells was slightly increased last year it appears that the yield was much less than in 1893, the decrease being 688,500,000 cubic feet. The pressure of the Welland wells has fallen very much owing to the large quantity delivered to Buffalo consumers, and last year it became necessary to erect a pumping station to maintain the flow. Obviously there is an error in the returns of miles of pipe line in 1892 or 1893, and the strong probability is that it is in those of the former year. The cost of labor, it may be observed, is chiefly for boring of wells and laying down of pipes.

PROSPECTS FOR IRON-MAKING IN ONTARIO.

A long interval of non-production in Ontario.

The last attempt to produce pig iron in Ontario appears to have been made in 1854, and since then the iron manufacturers of our province have been dependent upon outside sources for supplies of the material. Many attempts have been made during the forty intervening years to establish blast furnaces, but hitherto none have been successful. At the present time however a renewal of this important industry is in a fair way to be realized, and both Hamilton and Kingston have shown an interest in giving encouragement to capitalists with that end in view.

A blast furnace in course of erection at Hamilton.

In Hamilton substantial progress has already been made, and the outlook is now favorable for the blowing in of a coke iron furnace before the close of the present year. The promoter of this undertaking is Mr. J. J. Moorehouse of New York state, who has had large experience in iron-making in his own country, but more especially with charcoal iron furnaces in Connecticut. Having obtained satisfactory assurances of aid from Hamilton if works were located there, Mr. Moorehouse proceeded to organize a company of American and Canadian capitalists with an authorized stock of $1,000,000, and a charter for the Hamilton Iron and Steel Co. was taken out under the provisions of the Ontario Joint Stock Companies' Act.

Officers of the company.

The officers of the company at the first were: William Foster, jr., of New York, president; John H. Tilden of Hamilton, vice-president; William V. Reynolds of New York, secretary; and J. J. Moorehouse now of Hamilton, treasurer and general manager. These with Robert Jaffray of Toronto, John Milne, James Moorehouse and John G. Langdon of Hamilton, and A. M. Card of New York city composed the board of directors; but it is understood that Mr. Tilden will soon succeed Mr. Foster as president, and that an effort will be made to interest a larger proportion of Canadian capital in the concern.

The city's evidence of good will.

Hamilton has shown its good will to the company by granting a site of 75 acres, situated on Burlington bay, adjoining the city limits, in the township of Barton, at a cost of $35,000; together with a bonus of $40,000 in city debentures payable when the furnace is completed, and a further bonus of $60,000 for steel works if erected within a specified time. In addition to the site of 75 acres, the company is authorized to fill in and occupy the water front out to a line of eight feet of water. As dumping ground for furnace slag this is a great convenience, and when the work is finished the area of the location will be not less than 150 acres.

Contract for the furnace and buildings.

A contract for erection of necessary buildings, stack, ovens, boilers and engines, and all works above the foundations was let to the Philadelphia Engineering Works (Ltd.) on 28th October, 1893. In detail the contract calls for the following:

Blast furnace 16 ft. in bosh and 75 ft. high from floor of hearth.
Three fire-brick hot blast stoves, 19 ft. diameter and 60 ft. high.
Wrought iron hoisting tower.
One pair cross compound condensing blowing engines; steam cylinders 42 by 72 in. and 60 in. stroke; blowing cylinders 84 in. and 60 in. stroke.
Eight boilers 59 in. diameter, 24 ft. long with five 12 in. flues.
Draft stack for boilers 75 in. diameter clear and 125 ft. high, of steel plate lined with fire brick.
Cast house 50 by 160 ft.; engine house 47 by 65 ft.; boiler house 50 by 80 ft., and stock house 70 by 230 ft.

The contract provides that the furnace shall possess all modern improvements and be capable of smelting 200 tons of pig iron per day when using 60 per cent. ore and Connellsville coke; that it shall be constructed in all respects to obtain the very best economy in consumption of fuel and handling of materials, both in production of iron and manufacture of steel; and that it shall be furnished with blowing engines of the most economical type. It also provides that the blast shall be heated by three fire-brick hot blast stoves, of the Gordon-Cowper-Whitwell patents, with casing and valves suitable for a working pressure of 20 lb. per square inch, and all furnace construction and piping made suitable for this pressure.

Progress of the work.

The company began work on the foundations in November, 1893, and these were completed for the furnace contractors to commence the erection of buildings and plant in October, 1894, all the iron work and machinery for which are manufactured ready to be put together at their Philadelphia shops. The brick walls of the cast house, and the casings of the furnace stack and the hot blast stoves were erected during the winter; but the casing of the furnace was overturned during a heavy gale in March, and it was decided to discontinue further operations until the completion of the spur making connection with the Grand Trunk Railway, when all heavy machinery can be cheaply and expeditiously delivered on the ground.

Delays in executing the contract.

Under the original agreement the furnace should have been completed by 31st December last, but owing to unavoidable delays the time was extended to 1st July. A further extension has since been made to 1st October, as a consequence of the storm accident, and the officers of the company are sanguine that everything will be in readiness to blow in the furnace by that date. The total cost of the works, exclusive of the steel plant, will be over $400,000.

The following interesting reference to this enterprise is taken from the New York Iron Age, the chief authority on the subject of iron manufacture in America:

The New York Iron Age on the project.

"The situation of the furnace is an excellent one in many respects. It is just outside of the north east limits of the city of Hamilton, and close to the harbor, while the track of the Grand Trunk Railway is but half a mile away, connection with which has already been made.[14] Hence, when the furnace docks are completed, ore and fuel can be dumped close to the stack from ships or from cars, and the pig iron can be shipped to the chief consuming points by an all water or an all rail route. About 60 acres of the 170 acre tract given by the city is solid ground with no obstacles to furnace operations; the remainder is swampy and can be filled in as needed.

Advantages of the Hamilton furnace.

"The Hamilton furnace will have several advantages over all prospective competitors, which comprise the coke furnaces of Nova Scotia and of the United States, the competition of American iron having practically driven out Scotch iron from Ontario. In Hamilton itself there is a large quantity of pig iron consumed, and the town lies within about 100 miles of most of the other places in Ontario which afford an important market for this commodity. Hence, in freight on the pig iron shipped there will be an average of about $5 per long ton advantage for the Hamilton plant over its Nova Scotia competitors. It will also have an advantage in freight charges over its nearest American rivals, although a small one. But against American competition it will have the more substantial advantage of the duty and bounty of $4 and $2 per short ton, respectively, or, together, $6.72 per long ton. This sum in itself is almost equal to the whole cost of making pig iron in some sections of the United States at the present time. There is still another advantage which a blast furance in Ontario is offered, or at least will have an opportunity in sharing, over other pig iron establishments, not only in foreign lands, but in all other provinces in Canada. This is the bounty offered by the Ontario Parliament at its last session. This bounty is payable to the miners or producers of iron ore in the province, but as the conditions require that, in order to secure the bounty, the ore shall also be smelted in the province, it will be seen that the furnaceman's position will enable him to obtain much if not all of the benefit, especially if there be competition in the production of the ore. The sum of money appropriated for these iron bounties is $125,000, and is available for a period of five years from July 1st, 1894. The miners or producers are to be paid the equivalent of $1 per short ton of the pig metal produced from their ores, but not more than $25,000 is to be paid in any one year. If more ore is mined and smelted than the $25,000 at $1 per ton of pig would be sufficient to meet, the payments are to be on a pro rata basis per ton. Consequently if 25,000 short tons of pig iron be made in one year from Ontario ores, the makers will possibly enjoy in the reduced price of ore the equivalent of a bounty of $1 per short ton of pig iron; if 50,000 tons of iron be similarly produced in one year, the bounty would be equivalent to 50 cents per ton of smelted iron.

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[14] This statement is not quite accurate. The track has been graded nearly all the way, but completion of it was stayed by the refusal of the owner of a lot to sell the right of way over it at a price that was considered reasonable. This difficulty has been settled however, and it is hoped that connection with the Grand Trunk will soon be made. I was informed by officers of the company that the engines and all other necessary parts of the plant are boxed and ready for shipment from Philadelphia as soon as the spur line is built.

"From the foregoing, it will be seen that it is possible for the Hamilton furnace to enjoy for several years the equivalent of a protection of $7.84 per long ton on its product against British and foreign competition, and of $1.12 per long ton against Nova Scotian iron, besides the additional great advantage over the latter in freight for central Ontario markets. Great as these advantages seem to be in these days of keen competition, they are offset more or less by the conditions attaching to the supply of ore and fuel. With regard to the latter article, all its important competitors are more favorably situated than the Hamilton furnace. It will have to depend on Pennsylvania coke, which at the lowest prices can scarcely be delivered at Hamilton below $4 per ton. (Coke is in the free list of the new tariff.) But the important matter of ore supply has yet to be settled. That there are extensive deposits of rich iron ores in Ontario has long been known. Many of the deposits have been worked, and when prices were high thousands of tons of ore were shipped to the United States, the users bearing testimony to its excellent quality. But nearly all the discoveries and the mining have been of magnetite. To obtain a sufficient supply of hematite to mix with the magnetite in order to produce good foundry iron will probably be the first difficulty to be overcome by the completed Hamilton furnace. As iron ore is also on the Canadian free list, it may even be found profitable at the extremely low prices prevailing for lake Superior ores for the Hamilton company to use the product of the Michigan and Minnesota mines in whole or in part, at least until more extensive ore developments are made in Ontario. But these questions will have to be answered with regard to the conditions prevailing some months hence. It is scarcely necessary to add that when the Hamilton furnace is completed and started the results of its operation will be watched with keen interest by Canadian iron men and metallurgists, and by some

Supplies of ore and fuel.

American furnacemen near the border, who marketed 24,951 short tons of pig iron in Ontario in the fiscal year 1894."

The Kingston project.

The projected blast furnace and steel works at Kingston have not yet got beyond the stage of negotiation with the promoters, but hopes are entertained that they will go on if the city will grant aid along certain lines, the principal ones being a temporary loan to the promoters and a free site.

Ontario Iron Mining Fund to encourage the production of ore in the province.

In the session of 1894 the Legislature of Ontario made provision for the purpose of encouraging miners to open up and work the iron deposits of the province, conditioned upon the ore being also smelted in the province. For this object a sum of $125,000 has been set apart as an Iron Mining Fund, out of which the Treasurer may pay "to the miners or producers of ore upon all iron ores which shall be raised or mined and smelted in the province for a period of five years from the first day of July, 1894, the equivalent of one dollar per ton of the pig metal product of such ores." It is provided however that should a larger quantity of ore be raised or mined and smelted in any one year than the sum of $25,000 will be sufficient to meet the payments for at the rate here mentioned, then payments to the miners or producers of ore shall be made upon a pro rata basis, so that no more than $25,000 shall be paid for the produce of ores in any one year. It is also provided that payments out of the fund shall cease at the end of five years from the first day of July, 1894, and that any balance of the fund remaining after payment of earnings to that date shall be returned to the treasury of the province. The aid thus provided, together with the bonus of $2 per ton granted by the Dominion Government and the customs duty of $4 per ton, is equivalent to an advantage of $7.00 per short ton (or $7.84 per long ton) over all foreign competitors, a sum that is more than half the cost of the selling price of pig iron in the United States and Great Britain. For the supply of local markets in Hamilton, Toronto, London, Brantford, etc., there is the further advantage over foreign makers of iron which the cheaper freight affords.

Testing an iron ore deposit with the Government diamond drill.

The diamond drill purchased by the Government of Ontario to explore mineral properties has been steadily employed in testing the iron ore deposit of the Glendower mine since November, and it seems likely that as a result of its operations the mine will be re-opened this year.

PEAT FUEL AND PEAT LITTER.

Efforts to produce peat fuel.

The utilization of the large deposits of peat found in Ontario has been discussed in former reports of the Bureau, and is undoubtedly a matter of prime importance to the people of the province. It was hoped that the efforts of inventors and experimenters would result in producing a good article of peat fuel which could compete in both quality and price with coal and while giving employment to native capital and labor would do something towards defeating the natural monopoly which the coal-miners of Pennsylvania and Ohio possess of the Ontario market. This hope is as yet unfulfilled, though in one or two quarters the claim is made that the vexed problem of manufacturing an economic peat fuel has been solved. It is seldom that a new and useful process springs complete from an inventor's brain into the commercial world, and only the tests of time and trial, which are as yet unapplied, can show whether these claims are well or ill founded.

The utilization of peat for moss-litter.

Meantime an undoubted advance has been made in the utilization of the peat bogs of the province by the discovery that the upper surface of at least some of them is well suited for the manufacture of moss-litter, which is so extensively prepared and used in the countries of continental Europe, and is rapidly coming into favor in England and America. Its value as a bedding for horses and cattle is greater than that of any other article employed for the same purpose, and is due largely to the extraordinary capacity which it possesses for absorbing liquids and ammonia. In this respect its superiority over straw is very marked, and the cleanliness resulting from its use has a very beneficial effect upon the health of animals.[15]

Operations on the Welland bog.

The bog acquired by the Ontario Peat Fuel Company (Limited) is situated in the townships of Humberstone and Wainfleet, in the county of Welland, and comprises an area of about 5,000 acres, principally in the second, third and fourth concessions of those townships. The company has erected a plant on lot 9 in the third concession of Wainfleet, with the view of engaging in the manufacture of both moss-litter and peat fuel. The estimated capacity for the former is 30,000 tons and for the latter 75,000 tons per annum. The upper layers of the moss, consisting of undecomposed vegetable material suitable for litter, extend over the whole surface of the property to a depth of about two feet, and it is estimated will furnish about two million tons of the finished article.

Process of manufacture.

The process of manufacture is patented, and, after the first cutting up and removal of the moss from the bog, involves very little manual labor. The material is dried by a new process, which is not subject to interruption from wet weather, and can be carried on at all seasons of the year except in the severest winters. The process used to expedite the drying also very greatly shortens the time of manufacture, the completed article requiring not more than an hour for its production. The litter from this bog is said to be quite equal to the Dutch or German article, the color being bright, the quality fibrous and the absorbent powers high. The company has had no difficulty in contracting for the sale of an average output of 22,000 tons a year for five years in United States markets. Considerable quantities of moss-litter are used by large horse-car and other companies in New York and the larger American cities, which is imported exclusively from Europe, and there seems no reason why an article equally good and comparing favorably in cost from the Welland bog cannot be made to replace these European importations. An important home demand is also expected to arise when the merits of the litter become known.

The market for moss-litter.

The retail selling price in New York varies from $7 and $8 a ton upwards, according to quantity taken. In London the price in 1894 was 32 shillings a ton, which is said to have been an advance of about 50 per cent. over the current rates at the beginning of 1893. The company will put up the litter in tightly pressed bales of 225 lb. each, or eight to the short ton, bound with wire.

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[15] For fuller description of moss-litter and the methods of its manufacture and use, see articles on The Utilization of Peat, Report Bureau of Mines 1892, p. 195, and Moss-Litter, Report 1893, p. 139.

Shipping facilities from Welland.

The shipping facilities at the manufactory are good, the plant being situated within 1,000 feet of the Welland canal, and a mile and a half from lake Erie, with the line of the Buffalo and Lake Huron railway intervening. The Grand Trunk and Michigan Central railways are two and three miles distant respectively, and arrangements are being made with both companies to run spur lines to the manufactory. The company has also acquired the right to build a wharf and exercise shipping privileges on the canal.

Fuel value of the lower beds of the peat.

Below the mossy surface of the bog a heavier and more compact peat extends to a depth of four to twenty feet. It is the intention of the company to manufacture a compressed fuel by the Dickson patented process from this portion of the bog. By the Dickson method it is stated that the raw material can be converted into the finished article within a few minutes from the time it is dug up, and without the application of heat. The resulting fuel has a density of 93 lb. per cubic foot, or almost equal to that of anthracite coal. As the surface of the bog becomes converted into moss-litter the lower portions will be laid bare and the two operations can be carried on at the same time. Mr. A. A. Dickson is president, and Mr. J. R. Silliman secretary of the company, whose head office is in Toronto.

SECTION II.

GOLD IN ONTARIO: ITS ASSOCIATED ROCKS AND MINERALS.

By Dr. A. P. Coleman, Geologist and Mineralogist of the Bureau.

Since the discovery of the Richardson mine in the township of Madoc, in 1866, gold has been found at hundreds of points in Ontario, from the Madoc region in the east to the Lake of the Woods in the extreme west. In this distance of 900 miles there is nowhere a gap of more than about 100 miles between known gold deposits, except in the little explored region northeast of lake Superior, where gold has not been discovered for a stretch of 175 miles. It will be convenient to speak of three gold regions in the province, a southeastern one in Hastings county, a central one reaching from Wahnapitae to the Sault, and a western one extending from lake Shebandowan to the Lake of the Woods. A few isolated discoveries lie outside these areas, and it may be that future finds will connect the three gold regions into a single one, including the whole Archæan portion of Ontario.

Gold regions of Ontario.

Unlike most gold regions, Ontario has no placer deposits, a consequence of intense glacial action which has swept away all gold bearing sands and gravels and so mixed them with barren materials in the immense beds of drift found in the southern portions of the region as to make placer mining hopeless. It is said that colors of gold may be washed from the sands of Toronto island, and probably traces of placer gold could be obtained at many other points by perseverance in panning, but nowhere in paying quantities. In this respect Ontario resembles Nova Scotia and differs from Quebec with its Chaudiere placers, and still more from British Columbia.

Effects of ice action on gold occurrences.

Another important result of ice action has been the more or less complete removal of weathered products from the surface of veins, so that the sulphides which regularly accompany gold-bearing quartz in all parts of the world below water level are here found as a rule only a short distance beneath the surface; implying that no large amount of thoroughly free milling oxidized ore can be obtained from our mines, and that the more refractory sulphide ores must be treated from the very first. The points just mentioned account largely for the slow advance of gold mining in the province.

Purity and form of the gold.

The gold from our mines is unusually pure, resembling in this respect the gold of Nova Scotia rather than that of British Columbia. Assayers notice that Ontario gold ores, when free from galena or copper pyrites, yield buttons with little more silver than is accounted for as coming from the litharge or test lead employed in the assay. Probably the proportion of silver is generally less than five per cent., though exceptions occur to this rule. Dr. Lawson states that in some gold ores from the Lake of the Woods "silver occurs in the auriferous quartz veins, generally as an accessory mineral, in small quantities, but sometimes, as the assays of the Pine Portage mine show, in greater proportion by weight than the gold." [1]

Our gold appears in the usual forms as nuggets, scales, etc., and never, so far as I have observed, in crystals, though crystals of gold have been reported from the interesting new region of Wahnapitae. Specimens from that lake in the museum of the School of Practical Science, Toronto, show smooth planes, but apparently only an impress from adjoining quartz crystals.

MINERALS ASSOCIATED WITH GOLD.

Quartz and its characteristics.

Of the minerals associated with gold quartz is by far the most constant, so that miners and explorers are apt to call every gold ore, no matter what its composition, quartz; if, indeed, they do not refer to as a "quart," with the idea that a single specimen should be spoken of in the singular, not in the plural. The gangue quartz of Ontario gold ores varies greatly in character. Often as found at the surface it is rusty and porous, "good looking rock," while a short distance below it contains sulphides and is quite different in appearance. The quartz may take on crystal form and be more or less clear and transparent, as in some specimens from Wahnapitae; or it may be massive or bluish-gray, as in the ore from the Ophir mine in Galbraith township, or the Sultana mine near Rat Portage. Some of the latter quartz, which is distinctly schistose and has a crypto-crystalline appearance with thin bands of chlorite or hornblende running through it here and there, might properly be described as quartzite. In other regions the quartz is apt to be fine grained and milky or dull white, as at the Partridge mine near the Atik-okan, or the Ledyard mine in Belmont. From the latter locality come some beautiful specimens of white cellular quartz with specks of gold disseminated over the walls of the cells. In the same quartz Mr. McAree has observed small red jaspery concretions.[2] Sometimes the quartz is stained to a pale red with films of hematite, as at the Ray-Wiegand mine on the Seine river, or green with malachite, as in the McGowan mine near Parry Sound.

In texture then the quartz may form crystals or coarse or fine-grained crystalline masses, or it may be crypto-crystalline and compact. Its color may vary from pure white to greenish-black, or it may be stained red or brown or green with iron or copper compounds. It may be almost transparent, or only translucent, or quite opaque. It may be true vein quartz, or a schistose quartzite. A few other oxides occur in our gold ores, especially the brown hydrous and the red anhydrous oxides of iron in weathered surface ore. Vennor states that gold has been found embedded in the third oxide of iron, magnetite, in the Madoc and Marmora district, and that Prof. Bell of Albert College, Belleville, found oxide of tin in a specimen of ore from the same district.[3] A similar association has been observed at the Vermilion mine in the Sudbury region, where small amounts of cassiterite occur.

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[1] Geol. Sur. Canada, 1885, p. 143 CC.
[2] Papers of Engineering Society, S. P. S., p. 26, etc.
[3] Geol. Sur. Can., 1871-2, p. 131.

Sulphide ores.

Sulphides of one kind or another are almost universal accompaniments of ores of gold that have not been subjected to weathering, the most prominent of course being iron pyrites, whose brassy gleam may be seen in most of our gold ores. It displays the usual crystal forms, cubes with striated planes or pentagonal dodecahedra. Crystals an inch in diameter are sometimes found in the Belmont ores. The common occurrence of pyrite with gold is no doubt accounted for by the mode of transport and deposit of the metal, sulphate of iron having the power to dissolve small quantities of the metal. Any reducing agent, such as organic matter, destroys the solvent by forming sulphate of iron, the gold being deposited at the same time. This theory satisfactorily accounts for the particles of gold often found embedded in the pyrite. If the particles are above a certain size they are more or less completely liberated by crushing, and may be saved by amalgamation. Such sulphide ores are partially or wholly free milling. If the particles are very minute many of them will not be set free by simple crushing, and the ore is refractory. It is worthy of note that some of our ores which have been looked on as highly refractory, so that thousands of dollars have been spent on chlorination or other plants with which to treat them, have turned out to be almost completely free milling. An excellent example of this is to be found in the Sultana mine, from whose sulphide ores 92½ per cent. of the gold is extracted in the stamp mill, and the small quantity of concentrates obtained hardly pays for treatment.

Ir. n pyrites.

In the Sultana ore one frequently sees specks of gold embedded in the quartz entirely apart from the iron pyrites. It is clear that this gold cannot have been deposited in the way suggested above. Perhaps this and the nuggets sometimes found in pure white quartz at the neighboring Ophir mine have been carried in the form of a gold silicate, as suggested by Bischoff and other writers.

The cellular white quartz from Belmont doubtless once had its cavities filled with pyrite crystals like those now found below the level of weathering. The sulphide has been oxidized into sulphate and leached out, one stage of the process being perhaps the formation of hydrous sesquioxide of iron and of siderite.

I am not aware that the marcasite variety of iron pyrites has been found in our gold ores, but pyrrhotite, the lower sulphide, is not infrequent in the Lake of the Woods region.

Copper pyrites.

Small amounts of copper pyrites are often found accompanying the iron pyrites in our gold quartz, sometimes largely replacing it, as at Oliver Daunais' Wabigoon mine. The other copper sulphides, bornite or peacock ore, and chalcocite or copper glance, are much less common. In one very interesting deposit found last spring near Parry Sound these two minerals occur in large quantities in the quartz, far outweighing all the other sulphides, and small nuggets of gold may be enclosed in them or lie between the copper ore and the quartz.

Mr. Coste in his report on the Lake of the Woods region mentions the somewhat rare sulphide of copper, covellite, as occurring with iron and copper pyrites, bornite and other sulphides in the gold ores from that part of Ontario.[4]

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[4] Geol. Sur. Can., 1882-4, p. 15K.

Galena and zinc-blende.

The only other sulphides which I have observed or seen mentioned in connection with our gold ores are galena and zinc-blende. The former is often found at the Lake of the Woods and Rainy lake, and is there considered a favorable sign, since it is generally associated with free gold. The cause of this relationship is not easy to understand, for the galena itself does not usually carry any important amount of gold. Zinc-blende is found in small quantities in mines near Port Arthur and Marmora, but seems to have little influence on the gold contents of the ore. The sulphides of iron and copper seem much more efficient as gold bearers than those of the other metals.

Mispickel and tetrahedite.

The only compounds of arsenic or antimony found in our gold veins are mispickel and tetrahedrite. The latter mineral has been reported from only one locality, so far as I am aware, the Empire mine in Madoc, where Vennor found it forming small gold-bearing veins with calcite, magnesite and quartz in dolomite [5]. Mispickel, on the other hand, is rather widely spread in the gold deposits of the province, being found in small quantities in ores from the Lake of the Woods, and in immense amounts at the Gatling and other mines near Deloro in Marmora. The mispickel of Deloro occurs sometimes as very pretty rosette-like twinned forms or as crystals of prismatic habit, but more commonly in fine or coarse-grained masses. According to Prof. Chapman [6] it averages from one or two to seven or eight ounces per ton of gold, and the value of the ore is considerably increased by the large amount of arsenic it contains; but the ore proved so refractory that the expenditure of hundreds of thousands of dollars in elaborate reduction works resulted only in failure.

Rosette.

A quite similar ore was worked, apparently at a profit, many years ago at Goldberg, in Silesia, where the arsenic was made a valuable part of the output. It is probable that improvements in method may yet cause these mines to be valuable. In considering the province as a whole, one should remember that arsenic in amounts sufficient to make the ore very refractory is confined to this narrow belt of territory. The Belmont mines, a few miles away, show no trace of mispickel.

Sylvanite and

Tellurium occurs, apparently in only one locality in the province, in the sylvanite of the once famous Huronian mine west of Port Arthur.

other minerals.

The other minerals associated with gold in the province are not specially important. Free gold may sometimes be found in the silicates forming the wall of veins. A pretty specimen from Wahnapitae, now in the museum of the School of Practical Science, Toronto, contains several small nuggets completely enclosed in green chlorite. Vennor refers to the occurrence of gold in dolomite and calc spar, [7] and describes the wonderfully rich cavity of the Richardson mine in Madoc, where the first gold was discovered in Ontario. The gold was here found in a "reddish brown ferruginous earth in which were scattered fragments of a black carbonaceous matter, the latter showing when broken small flakes and scales of the metal." [8] Specimens of free gold from Marmora, in the School of Science collection, are associated with a somewhat weathered siderite. Probably some of the rusty quartz with free gold from this and other parts of the province results from the decay of siderite or other carbonates rich in iron rather than from the weathering of sulphides.

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[5] Geol. Sur. Can., 1866-69, p. 168.

[6] Minerals and Geology of Central Canada, p. 307.

[7] Geol. Sur. Can., 1866-69, p. 167.

[8] Ibid., p. 165.

THE GOLD-BEARING FORMATIONS.

Laurentian,

Turning now to the rocks in which the gold deposits of the province occur, we find that they are all very ancient, most of them Archaean. The south-eastern region, that of Marmora, Madoc, Belmont and other townships, is probably the most ancient, belonging to what Vennor calls the Hastings series, believed by him to be the equivalent of the lower Grenville series of Logan, *i.e.*, to the lower portion of the upper division of the Laurentian. It is possible however that these rocks are really a small area of greatly modified Huronian. The remarkable gold-bearing deposit of Parry Sound is probably of the same age. All the other important gold districts are Huronian, if we assume that Lawson's Keewatin is in reality of that age.

Huronian,

and Keweenian.

Dr. Chapman however has obtained gold from a vein in Keweenian rocks at the Enterprise mine on Black bay, lake Superior; and gold has been found in the Animikie, north and east of Port Arthur,[9] showing that the precious metal does occur in rocks younger than Huronian, probably Lower Cambrian.

Eastern region.

Lithologically, the rocks in which gold has been found in Ontario vary greatly. Vennor describes the famous Richardson mine as occurring at the contact of a "chloritic and epidotic gneiss with a silicious ferruginous dolomite." It was in a cavity at this contact that the thousands of dollars worth of rusty earth thickly spangled with flakes of gold were found, which roused a gold fever the like of which has never been experienced since in the staid province of Ontario. In several other parts of the Hastings series Vennor finds gold in veins running through dolomite, in silicious dolomite or at the contact of mica slate and dolomite. With the dolomite are mentioned various schistose rocks, talcose, micaceous, chloritic and hornblendic. So far as mining experience goes in Hastings, the deposits in connection with dolomites are merely pockets, sometimes rich, but quickly exhausted. Vennor believes that the gold of the region is in close association with the summit of an iron bearing band.

The only specimens of country rock from the region which I have examined are from the Belmont mine. The specimens, which are greatly weathered, consist of diorite, perhaps originally diabase, and chloritic schist. The latter contains a large amount, almost 50 per cent., of a carbonate, calcite or dolomite. Mr. McAree, who examined the country rock of the Crawford mine in the laboratory of the School of Science, found it to be weathered diorite, with chloritic schist in the walls.[10]

Central region.

Passing to the central gold region, the rocks containing the gold deposits about lake Wahnapitae have, so far as I am aware, never been carefully examined, though Bell maps them as Huronian with eruptive masses of diabase and diorite, the Huronian being defined as consisting of a variety of crystalline schists and strained clastics, such as greywacke. The country rock of the Vermilion mine is Huronian, but of just what character I am not aware.

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[9] Min. and Geol. Central Canada, p. 301, etc.
[10] Papers of Eng. Soc., S.P.S., p. 26, etc.

A specimen of the country rock of the Ophir mine in Galbraith township, submitted to me by Mr. Blue, Director of the Bureau, though greatly weathered, is pretty certainly a diorite.

Western region.

Going still farther west we find some gold-bearing veins in the dark Animikie slates north and west of Port Arthur. No doubt the eruptions of fine grained diabase which traversed these rocks and covered them with widespread beds of lava have had a great influence on the formation and filling of the gold veins, as well as those of silver, in the region.

The Huronian mine, unique in Ontario as containing the rare mineral sylvanite, doubtless occurs, as its name suggests, in the Huronian, but I have not seen any detailed description of the enclosing rocks. The country rock of the gold bearing veins to the west of this is generally Keewatin (Huronian) or Laurentian near the contact of Keewatin, the only exception being the Shoal lake district, where the gold occurs in granite.

REPORT ON THE RAINY LAKE GOLD REGION.

Having been appointed Geologist and Mineralogist to the Bureau of Mines of the Province of Ontario in January, 1894, I was instructed by the Director, Mr. Archibald Blue, to prepare for a summer's work in the Rainy Lake gold region. Dr. John Burwash of Victoria University, Toronto, formerly Mineralogist to the Province of New Brunswick, was appointed my assistant. The necessary instruments were obtained, the Rice Lake canoe belonging to the Bureau of Mines was handed over to us, and, all preparations having been made, we left Toronto on June 17th for Rat Portage.

Outfit for the summer's work.

Here another built canoe was bought, our camp equipment was completed, and William Margach, jr., was engaged as canoeman. After two or three days spent in visiting the Sultana mine and other points of geological interest in the neighborhood, we took the steamer Monarch for Fort Frances,[11] and there completed the party by engaging two half-breeds, John Vincent and Pierre Mainville, as cook and canoeman.

Outlines of the field explored.

Sand Point island was made a base from which to study the geology of the central part of Rainy lake with some detail, so as to become familiar with the characteristic rocks with which we were to deal. Seine bay and the Seine river with its expansions, Shoal and Wild Potato lakes, were traversed as far as Sturgeon Falls. Bad Vermilion lake was next taken up, and then following Little Turtle lake and Sand Island river, we returned through Redgut bay to Rainy lake. Crossing by Grassy Portage and other bays, the two new townships of Halkirk and Watten, then under survey, were examined, and the party returned to Fort Frances on the 18th of July.

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[11] Often, but erroneously, written Fort Francis. In a letter to Mr. J. F. Whitson of the Crown Lands surveys branch, dated January 18, 1894, Mr. Jabez Williams, H. B. Co. factor, says: "Fort Frances is named after Lady Frances Simpson, wife of Governor Sir George Simpson, who used to pass by this route on his trips of inspection of the company's posts."

During this canoe trip nearly all the gold mining locations of this part of the region were visited, studies were made of the veins and country rock, and specimens collected for further examination.

After a day or two spent in refitting and in visiting the new stamp mill at Rainy Lake city, Minnesota, which was working on ores from the Little American mine, the first mine in operation on the lake, we turned northwards, passing through Northwest bay, lake Despair and Clear Water lake to Pipestone lake. From this point we turned eastward, over Strawberry and other lakes, to the southwestern end of lake Manitou. The mining locations on the upper portion of the last lake were examined, and passing through a chain of small lakes we reached, on August 14th, the Canadian Pacific railway at Wabigoon. Here the two half-breeds were paid off and returned to Fort Frances with a bark canoe, while the rest of the party returned to Rat Portage by rail. The party now disbanded, Dr. Burwash returning to Toronto, while I undertook a number of small expeditions, visiting several of the mines on the Lake of the Woods and near Rossland.

I then proceeded to Savanne with one of the canoes and, engaging a white man and an Indian as canoemen, made a rapid journey via Lac des Milles Lacs and other lakes to the Atik-okan river. It was my intention to go on to the gold mining locations on the upper Seine, but forest fires and the exceedingly low water in the creeks hampered the work so much that the trip was cut short at Osinawe lake, and I returned to Savanne, reaching it on September 1st. On the way home to Toronto I visited some of the famous iron mines of Minnesota and copper mines of Michigan.

Except for unusually high water on Rainy lake early in the summer, which covered many interesting outcrops along shore, and low water toward the end, interfering with canoe navigation, as well as the too prevalent forest fires, the season was a particularly favorable one for geological work. The men employed, both whites and Indians, proved good and efficient.

Lawson's Report on the Rainy Lake region.

In studying the mineral resources of the Rainy lake country, we found one work indispensable, Dr. Andrew C. Lawson's Report on the Geology of the Rainy Lake Region, Part F of the annual report of the Canadian Geological Survey for 1887. It was constantly in our hands while we were in the region it covers, and it has been made use of very often in the preparation of the following report. Dr. Lawson's work was of a singularly able and original character, and, while all his conclusions may not turn out to be correct, the fresh points of view which he suggests and the careful and accurate observations which he records are of great value to a geologist working over the same ground. The map accompanying his report and embodying its results is admirable, both from the geological and the topographical point of view, and is highly appreciated by every one having occasion to visit the country as explorer, steamboat captain, tourist or geologist. The sheet is unfortunately on rather too small a scale, four miles to the inch,[12] but still is clear and well executed, so that a guide is almost unnecessary on the routes which it covers. The geological coloring of the map is, according to our experience, very correct along the water courses, though a few comparatively unimportant points are corrected in the following report. Inland, where the country is inaccessible by canoe, the outlines of the areas covered by the various rocks are of course somewhat hypothetical, and will no doubt need minor adjustments.

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[12] The Lake of the Woods sheets, published in 1885, and prepared by Lawson and his assistants, are on the scale of two miles to the inch, which gives room for greater geographical detail.

Russell's map of the Manitou and upper Seine regions.

For portions of the mining region, like the Manitou country and the upper Seine river, which extend beyond the limits of the sheet, the maps published by Mr. A. L. Russell of Port Arthur are very useful, giving the canoe routes and surveyed locations. Mr. Russell's maps do not, I believe, cover the upper Manitou, and one must have recourse to tracings from the map in the Ontario Crown Lands Department, which covers all that has been surveyed, and gives also those parts of the shore line which were mapped by the Geological Survey some years ago in preparation for a new sheet of the geological map not yet published. Up to the present the Geological Survey of Canada has published two sheets of the Lake of the Woods region, the Rainy Lake sheet, and a sheet just to the southeast, embracing Hunter's island and adjoining portions of Ontario to the east and west. Dr. G. M. Dawson, Director of the Geological and Natural History Survey, has been kind enough to inform me that the sheets, including lake Manitou and the Seine river east of Wild Potato lake, with some others, are under way. It is to be hoped that under the vigorous new director we shall soon have geological maps covering the whole of this part of. Ontario, which is so interesting and important from the economic side.

Winchell and Grant's Report.

Much of the present report was written before "A Preliminary Report on the Rainy Lake Gold Region" by H. V. Winchell and U. S. Grant of the Geological Survey of Minnesota[13] was received; but advantage has been taken of it to add some points of interest to the account of the Little American mine and the Shoal Lake mining camp. A useful geological map, mainly taken from Lawson's, adds much to the value of their report.

Acknowledgments.

The writer of the present report wishes to express his gratitude to the many friends who have aided in the work, officials of the Crown Lands Department of the province, members of the Hudson Bay Company at Rat Portage, Fort Frances and Savanne, and many miners and prospectors; the latter, generous and hospitable men, rarely overburdened with this world's goods, but perennially hopeful for the future. They are a class who are of much importance to the province, and yet who seldom reap the full reward of their labors and privations.

THE GEOGRAPHY OF THE REGION.

The field, and ways of reaching it.

The newest gold region of Ontario, that of Rainy Lake, lies east of the Lake of the Woods, south of the Canadian Pacific Railway, west of Lac des Milles Lacs and north of the Itasca and St. Louis counties, in Minnesota. It may be reached by a week's hard paddling from Port Arthur, by four or five days' canoeing from Savanne, or by two or three days from Wabigoon down the Manitou route, as well as from other points on the railway; but the easiest route in comfort of travel and the shortest in time is by the Canadian Pacific to Rat Portage and thence by steamer through the beautiful Lake of the Woods and up the charming Rainy river to the head of navigation at Fort Frances. Once above the fall of 22 feet at this point, about two and a half miles of journey bring one to Rainy lake. If the unfinished lock at Fort Frances were completed there would be uninterrupted navigation from Rat Portage to Sturgeon Falls on Seine river, about 50 miles east of the fort. The trim and beautifully placed village of Fort Frances and its less finished neighbor, Koochiching, across the river in Minnesota, are connected by small steamers with Rainy Lake city fourteen miles to the east, on the southern shore of the lake near the Little American mine. The lake may also be reached from Duluth and other points to the south by taking a train to Tower and then traveling north by stage and water to Rainy Lake city; but this route is not a favorite even for Americans, many of whom come round by Port Arthur and Rat Portage.

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[13] Part III of the Twenty-third Annual Report.

The gold region as a whole is almost entirely included in territory reached by Rainy lake and its tributaries, Manitou river and lake to the north, and the Seine with its lake expansions to the east; so that Fort Frances is the natural starting point for prospectors and explorers. The heavy machinery of the stamp mill at Rainy Lake city came in via Rat Portage and Fort Frances. It is but a question of time however when railways will enter the region from the south, and perhaps also from Port Arthur on the east. By utilizing the water-power of Seine river an electric railway is one of the possibilities.

Physical characteristics of the country: the Land of a Thousand Lakes.

The general physical characteristics of the country are similar to those found in other glacier swept Archæan tracts, such as Muskoka and the Thousand Islands. In contrast with the latter one might call the region as a whole the "Land of a Thousand Lakes," giving a wider application to the poetical name attached by early French explorers to a body of water lying to the east. It is a land of innumerable lakes, with unnumbered bays and islands. Rainy lake is of course the largest, reaching 25 miles north from its outlet near Fort Frances, and nearly 40 towards the east. Its general shape is that of a capital L with an exceedingly ragged outline. The lake scarcely anywhere presents a stretch of more than ten miles of open water, and yet its coast line, without counting minor indentations, is probably at least 600 miles, or more than that of lake Ontario, and if one included the shorelines of its islands, probably the mileage would be almost doubled. The other lakes of the region, like the Manitou and Pipestone, though much smaller, imitate Rainy lake in their endless channels, inlets, sounds, straits and ramifying bays; so that the complication of land and water is most puzzling to the explorer. It is probable that within the region covered by Lawson's Rainy Lake sheet, 50 miles by 75, there are thousands of miles of shoreline. Along most of these shores the rock is well exposed, so that conditions could hardly be better arranged for the work of the geologist and prospector. There are however a few lakes, such as Furlonge, where the woods come right down to the shore,

Favorable conditions for exploration.

and rock is rarely to be seen; but in many cases rocky slopes or walls rise directly from the water, so that much may be seen without even getting out of the canoe.

Forest fires.

Inland the case is different. Soil and forest growth cover the surface, and rock crops out only here and there as weatherworn ridges, unless, as is too often the case, fires have swept off the Norway and white pine, leaving a tangle of fallen trunks upon the calcined surface. A second visitation of fire, as at some points on the shore of lake Manitou, may sweep off soil, fallen timber and all, leaving bare slopes and crests of rock which will probably not be covered with vegetation for generations to come. These fires, though to a certain extent helpful to the prospector, must in the long run be very injurious to the country as a mining region, robbing it of the timber necessary for fuel, as well as for building and mining purposes.

An ideal region for canoeing.

Dr. Lawson graphically describes this "rocky lake country" in an early part of his report, and points out the fact remarked by every observer that it consists of a series of larger and smaller rock-rimmed basins each spilling over into the next lower. These chains of lakes make an ideal region for canoe navigation, and they are so numerous and the water-sheds so narrow that with a little management and a few long portages one can paddle across country in almost any direction.

The basin of Rainy lake a weathered and ice carved plain.

Lawson puts the level of Rainy lake at about 1,182 feet above the sea. The deepest sounding which he obtained is 110 feet, and he speaks of the highest point, in the Kishkutena ridge, as 600 feet higher.[14] The region as a whole, in spite of its variety of surface, contains nothing that can be described as a mountain, and must be looked on as an ancient base-leveled surface, a plain whose contorted and unequally resisting rocks have been weathered and ice carved into the present confusion of hills and water filled hollows. Confusion is however an unsuitable word, for Lawson has pointed out that the longest axis of the ridges as well as of the lakes conforms to the strike of the schists, wherever they are exposed, and that it is only in the granite and gneiss, where a schistose structure is not marked, that lake forms are quite irregular. Here as everywhere the topography has a foundation in the geology of the country.

Waters and fish of the lakes.

The water of Rainy lake and many of its satellites is brownish and rather turbid, though not unwholesome. To me it appeared to have a rainy taste, perhaps explaining the origin of the name. Its waters contain whitefish, pickerel and jackfish, but not trout. Manitou and Clearwater, as well as several other smaller lakes, have exquisitely clear water and are the home of fine trout. A few of the smaller lakes are silting up and filling with mud and weeds, so that every stroke of the paddle stirs up a swarm of foul bubbles.

Areas of rich bottom lands.

While most of the district is of the rocky lake type just described there are a few portions covered by alluvial clay, where there is level fertile soil, once lake bottom, now more or less perfectly drained by winding sluggish rivers here and there expanding into marshy lakes. The largest area of good land is found, as is well known, along Rainy river, but considerable tracts occur along the Seine and parts of Turtle river. In such parts of the country the smaller creeks loose themselves among pond lilies and weeds, favorite feeding grounds of the increasing moose; and canoeing becomes slow and toilsome, while outcrops of rock are few and far between. Many of the small bands of Indians, mostly pagans, who thinly people the country have their reservations on these rich bottom lands.

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[14] Geol. Sur. Can., 1887, p. 14F.

All the waters of the district under consideration empty finally into Red river, and thus reach Hudson bay.

GENERAL GEOLOGY OF THE RAINY LAKE REGION.

For a detailed account of this subject the reader is referred to Dr. Lawson's report, where some very difficult but interesting problems relating to the Archæan are attacked in a bold, original way, and the results of careful observations are described, giving a basis of facts to support his views. For our purpose however an outline sufficient to make the work that follows intelligible is all that is required.

Divisions of the Archæan formations.

The whole region belongs to that most ancient of formations, the Archæan, which Lawson divides up as follows:[15]

Archæan	Upper division.	a. Keewatin. (Huronian ?)
		b. Couchiching.
	Lower division.	Laurentian.

The Lower Laurentian, and its characteristics.

In eastern Ontario the Laurentian has been divided into a lower series, the Ottawa gneiss, and an upper one, the Grenville, which contains crystalline limestones. Only the lower series is represented in the Rainy Lake region, where the Laurentian consists of various granitic and gneissoid rocks. The granites contain quartz, felspar, chiefly orthoclase, and biotite, the black variety of mica, or instead of biotite, hornblende. In most cases the granite seems to merge at one point or another into gneiss, consisting of the same ingredients. The foliation or schistose structure of the gneiss is often not very marked, and the rock may then be called a granitoid gneiss. The quartz of the granite may be absent more or less completely, when the rock becomes syenite with the corresponding gneissic form. This series of rocks varies from quite fine grain to very coarse; and in many cases the orthoclase felspar forms large oblong crystals, often Carlsbad twins, imbedded in a finer grained ground mass, so that the rock becomes porphyritic. In color these rocks vary according to the tinge of the felspar and the amount of the dark minerals, biotite and hornblende, so that all gradations from almost white to dark gray occur, the general tone being reddish.

COUCHICHING SERIES.

Couchiching series of the Upper Archæan.

Resting on the Laurentian toward the southern part of Rainy lake we find a series of monotonous rocks which Lawson has named Couchiching,[16] gray cleavable schists consisting of quartz and fine scales of mica, with or without felspar; in the latter case forming gneiss. These fine grained, dull gray or brownish, very cleavable mica schists and gneisses are generally easily distinguished from the granitoid gneisses of the Laurentian; Lawson considers this group of rocks to be a series of sediments which have undergone alteration. They often contain garnets and other minerals, suggesting metamorphism. Lawson assigns a thickness of about five miles to the Couchiching series.[17]

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[15] Geol. Sur. Can., 1887, p. 22 F.

[16] Ibid. p. 99 F., from the Couchiching rapids near Fort Frances.

KEEWATIN-SERIES.

Character of the Keewatin rocks.

Above the Couchiching, where the latter is found at all, comes the series of rocks, probably Huronian, named by Lawson Keewatin.[18] The majority of them are green, but some are pale yellow or brown. Among the green rocks there are massive beds with no tendency to cleave in one direction more than another, so that they may be looked on as traps or greenstones, in reality more or less metamorphosed diabases having the ophitic structure of slender prismatic felspars, or less often the granite type of basic rock, gabbro. One can rarely see the twin striations on the felspars of these rocks, so decomposed are they; and the augite which forms the other chief constituent is generally changed to some chloritic mineral or hornblende. In the field the diabases and gabbros are often hard to diagnose, so that the term greenstone is allowable for these hard, dark green, massive rocks. They appear to pass into somewhat schistose portions, probably the result of pressure and shearing forces acting on originally massive beds. Another more schistose group is considered by Lawson to be of sedimentary origin, probably altered volcanic ashes. They form soft, often lustrous, chloritic schists with a little quartz or felspar or some carbonate between the layers of chlorite scales; or hard green hornblendic schists, or a mixture of the two, the hornblendic variety prevailing when near the contact with the Laurentian. In a few cases the Keewatin seems to form a dark mica schist close to the granitoid gneiss. The massive beds of greenstone are often interbedded with these schists. Conglomerates, fine-grained to very coarse, containing rounded pebbles or stones of various materials such as quartz, greenstone, gneiss or quartz porphyry, are associated with the green schists in some places, apparently as basal beds. The matrix in which these pebbles are imbedded is green schist like that just described, the layers of chlorite or hornblende folding closely round the included stones. It is clear that when these conglomerates were laid down there were sea-washed shores on which solid gneiss and other rocks were worn and rounded just as they are to-day. The boulders themselves have pretty successfully resisted the subsequent metamorphic influences, while the clayey cement, perhaps partly volcanic ash, has been changed into green schist.

Schists and conglomerates.

Greywacke and talc.

In some parts of the Keewatin greywacke occurs, a dull gray or greenish-gray rock made up of irregular angular fragments of quartz and other minerals. A greenish-gray impure talc, soft enough to be scratched by the thumb nail, is found in a few places, as at the upper end of Pipestone lake, a material long used by the Indians of the region for carving into pipes.

Upper section of the Keewatin.

An upper section of the Keewatin is quite different from this lower basic series of greenish rocks. The second group consists of pale yellowish or brownish or flesh-colored rocks, an acid series rich in silica or quartz. The commonest forms are felsite schists, very fine grained, easily cleavable rocks, consisting mainly of quartz, unstriated felspar and minute scales of pale mica sericite or muscovite). Little fragments of quartz and crystals of felspar can sometimes be distinguished in the fine grained ground mass, reminding one of an eruptive rock, quartz porphyry. Lawson supposes that the once massive porphyry has been sheared or squeezed into the very cleavable felsite schist. In some instances there are masses of undoubted quartz porphyry enclosed in the schist, perhaps more resistent portions of the original rock. The pale acid (or silicious) rocks are often closely intermingled with the green basic ones, a layer of the one being followed by a layer of the other, and so on alternately. Lawson looks upon these pale Keewatin rocks as the result of a second set of volcanic eruptions, the more acid lava flows following the basic eruptions which gave rise to the beds of greenstone and chlorite schists so generally characteristic of the Keewatin.

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[17] Geol. Sur. Can., 1887, p. 102 F.

[18], Ibid. 22 F, etc.

Thickness of the series.

Lawson determines the thickness of the Keewatin beds to be about five miles, judged by a section near the lower end of Manitou lake. W. H. C. Smith, in his report on the Hunter's Island district, concludes however that the Couchiching beds, in one place at least, have been thrown into numerous folds, which have been squeezed together so that a section across their eroded edges gives a quite false idea of the original thickness,[19] and it is possible that the same may apply to the Keewatin.

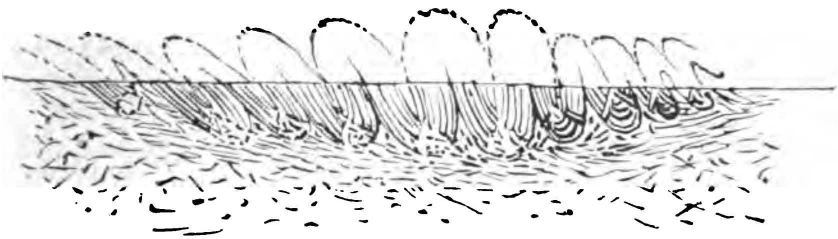

Fig. 1. Folds in Couchiching—after W. H. C. Smith, p. 55 G, Geol. Sur. Can., vol. V., Part I.

RELATIONS OF ARCHAEAN ROCKS.

Arrangement of Laurentian and Huronian areas.

The geology of the region, as worked out by Lawson, shows very interesting relations between the rocks just described. The granitoid gneiss and other members of the Laurentian occupy wide areas, having rounded outlines, and in most cases the foliation, i.e., the direction in which the mica or hornblende plates are arranged, is parallel on all sides to the margin of the area. Stretching around these Laurentian areas we find the Huronian rocks in narrow bands, enclosing the gneiss in a wide meshed network. Where two strands of Keewatin come together in the network they spread out into curves, so that the points of junction are the widest parts of the bands. The foliation of the Huronian schists is generally parallel to the adjoining edge of the gneiss. The "strike" of the schists, the direction of their cleavage, changes from point to point as the band of Keewatin curves round the areas of gneiss.

Attitude of the green schists, and

The attitude of these green schists is remarkable. They hardly ever lie level or nearly so, but are almost always steeply tilted and often vertical. In most parts of the region the green schists come directly in contact with the gneissoid rocks, but along the southern shores of Rainy lake and the Seine river wide bands of the gray Couchiching mica schist or gneiss intervene between the Keewatin and Laurentian. In the northern part of the region and on the shores of the Lake of the Woods the Couchiching appears to be absent. If the schistose layers of the Couchiching and Keewatin represent an original bedding of volcanic ash and other sediments laid down in water, and not a structure imposed on them since by earth movements, we must suppose that these beds once lay nearly horizontally on the rocks beneath. How comes it that we now find them usually on end? Lawson has a daring explanation of this state of affairs. The underlying rocks, gneisses or whatever they were in the beginning, were deeply buried by the rocks above, became gradually softened by heat from the earth's interior, until they formed a plastic or even fluid mass which rose in huge swellings, lifting the Huronian in some places and in others nipping the beds into sharp downward folds between the swellings. That the molten or semi-molten gneiss penetrated the schists, and carried off great fragments of them at their edges, Lawson has conclusively proved, and the evidence is clear to any observer among the islands of the central part of Rainy lake. This is such an astounding thing, especially on the scale presented in this region, that the present writer paid special attention to the point, and believes that Lawson's explanation is correct.

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[19] Geol. Sur. Can., 1890-91, p. 55 G.

Lawson's theory as to the origin of it.

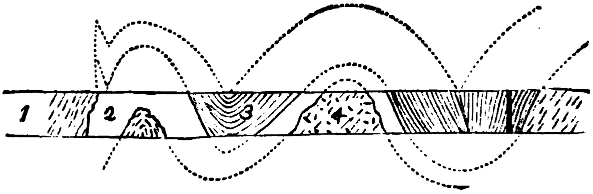

Fig. 2. 1, Gneiss; 2, Couchiching; 3, Keewatin; 4, Granite. Folds of Couchiching and Keewatin—after Lawson.

The Keewatin schists older than the Laurentian.

If we date the age of a rock from the time when it solidified, the Keewatin schists, generally considered Huronian, must be older than the underlying Laurentian gneisses, which were fluid enough to carry off blocks of the already solid green schist. It need scarcely be remarked that the Huronian is generally held to be of much later age than the Laurentian, and to lie unconformably upon it. Of course this view may be quite correct in some other regions. If we suppose that a layer of Huronian was lifted on the shoulders of the upswelling gneiss or granite, it must have been greatly broken and fissured, so that it has been easily acted on and removed by erosion; or perhaps it was in part dissolved and lost to view in the molten rock beneath. The folds squeezed in, being compressed and rendered more solid, as well as protected by the hard gneiss on each side, have withstood the wear and tear of ages much better.

ERUPTIVE GRANITES AND GABBROS.

Later eruptions of granite and gabbro.

After the two main rocks had taken shape the era of disturbances was not yet over, for there appear to have been eruptions of granite and gabbro in several parts; and still later dykes of diabase forced their way through fissures in both Laurentian and Keewatin. These eruptive granites, which are flesh colored or greenish and often very siliceous, break through both Laurentian and Keewatin, and are interesting as occurring in at least one case as the country rock of promising gold bearing veins. The other plutonic rock, gabbro, differs greatly from the obscure gabbros interbedded with the Keewatin schists. It is best shown around Bad Vermilion lake, where the rock varies from medium grained green varieties in which the felspar crystals have idiomorphic form, to almost white anorthosite made up chiefly of immense plagioclase crystals. A more detailed account of some of these interesting rocks will be given in the petrographical portion of this report.

Diabase dykes.

The diabase or trap dykes are the youngest rocks of the region and often form wide veins of dark rock, striking northwest and southeast. Lawson speaks of them as being commonly from 60 to 150 feet wide, and notices the remarkable difference in coarseness of grain between the center and edge. There are also very much narrower dykes, however.

DISTRIBUTION OF LAURENTIAN AND HURONIAN IN THE RAINY LAKE REGION.

Irregular distribution of Laurentian and Huronian rocks.

The various rocks which have thus far been described are very unequally distributed. By far the larger portion of the region mapped on Lawson's Rainy Lake sheet is covered with Laurentian gneiss of varying kinds. One large irregularly rounded area occupies most of the middle of the sheet and measures 45 miles from northeast to southwest, by 30 in the other direction. Its southern boundary is approximately the east and west arm of Rainy lake and 30 miles of Rainy river; Clearwater and Pipestone lakes lie to the northwest; Furlonge and Pickerel lakes to the north; Pickwick and Big Sawbill lakes and Redgut bay outline it toward the northeast. The northern part of Rainy lake with its torn and tattered outline occupies its centre. Around the gneiss an irregular band of Keewatin stretches, widening and narrowing from point to point, cutting off a small triangular portion with a slender strip of schist at the western end, and thinning out to less than a half mile in width at Redgut bay to the east. This band of Keewatin, as shown on the Rainy Lake sheet, divides off the central Laurentian area from five other important areas of the same rocks, one southwest of Rainy river in Minnesota, a second to the west, stretching from Kishkutena lake to the Lake of the Woods, a third to the north beyond Bluff and Missus lakes, a fourth to the northeast, but containing some straight or curved bands of Keewatin, and a fifth east of Little Turtle lake extending 22 or 23 miles from west to east, bounded approximately by Little Turtle river on the south and a rather narrow bow-shaped band of Keewatin on the north.

Couchiching and

A great stretch of Couchiching covers the part of the sheet south of Seine river, Rainy lake and Rainy river; and smaller bands and patches of it border the isolated body of Keewatin lying in the northeast angle of the "L" of Rainy lake.

Keewatin bands.

The Keewatin in the southern part of the sheet is mainly of the green, basic type, composed of chloritic and hornblendic schists with intercalated beds of diabase; but toward the north, the upper acid series of schists and agglomerates, altered felsites and quartz porphyries, becomes important especially toward the north side of the wide Keewatin band enclosing the northern end of Pipestone lake, Yoke, Strawberry and Missus lakes, and the southwestern end of Manitou lake.

Outcrops of granite.

There are some minor geological features of importance,—the distribution of the granite bosses, for instance. Many of them come up through the Laurentian granitoid gneiss, a number of small ones are noted along Northwest and Shelter bays west of the north arm of Rainy lake. An oval patch more than ten miles long is placed on Bat lake a little south of Manitou. Another large mass of granite encloses Spawn inlet north of Redgut bay in the northeastern Laurentian area. Lawson indicates on his map that the foliation of the gneiss curves concentrically round these two large granite masses. Outcrops of granite occur on a smaller scale in the Keewatin also, as on the shores of Pickerel lake, at the south end of Smooth Rock lake, and between Shoal and Bad Vermilion lakes, in the last instance associated with gabbro. Doubtless many more small granite bosses than are indicated on the map will be found by more detailed examination. One which was not placed on Lawson's map was found by us to cover several square miles of country around Caribou lake, just touching the southeastern corner of Manitou lake.

Granite bosses on Bad Vermilion lake holding gold bearing veins.

The most interesting group of eruptive masses is that in the green Keewatin on the shores of Bad Vermilion lake, where three granite bosses are more or less enclosed in coarse grained gabbro or anorthosite. Lawson suggests that they represent the roots of an old volcano or group of volcanoes, perhaps one of those which gave rise to part of the volcanic ashes and lava flows now metamorphosed into the Keewatin schists, etc.; the first eruptions being of basic material (gabbro) and the later ones of more acid rock (granite).[20] The discovery of rich gold bearing veins in this eruptive area makes it of especial importance.

Eruptive dykes.

Besides these eruptive masses there are also numerous veins or dykes of eruptive rock in the region. Veins of very coarse grained granite or pegmatite appear sometimes in the Couchiching schists and also in the granitoid gneiss; while dykes of dark diabase or trap, generally with a southeast and northwest strike, are not uncommon.

Serpentine bands.

A few bands of serpentine occur in the region, as at the south end of lake Despair, and the north end of Clearwater lake, at the latter point accompanied by a small amount of chrysotile (ordinarily called asbestos). These serpentines, which no doubt result from the weathering of some basic eruptive rock, probably olivine diabase, occur only in the green Keewatin.

CHARACTER OF THE ORE DEPOSITS OF THE RAINY LAKE REGION.

Bedded and fissure veins.

The more important ore deposits in the neighborhood of Rainy lake are of two kinds, bedded or segregation veins and true fissure veins, the latter being much less common than the former. Bedded veins are interstratified with the enclosing rocks, have the same strike and dip, and are generally lenticular in shape. They are less likely to be continuous in strike and depth than true fissure veins, which cut across the stratification or foliation of the country rock. In origin however the two classes of veins are less distinct than is sometimes imagined. They are both fissures filled with minerals deposited from circulating water; the fissures probably are formed in somewhat the same way, and both generally occur where faulting has taken place.

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[20] Geol. Sur. Can, 1887, p. 57 F. Winchell and Grant appear to reverse this order, making the gabbro later than the granite. Part III, 23rd An. Rep. Geol. Sur. Minn., p. 85 and 86.

Formation of bedded veins in schistose rocks.

Bedded veins are pre-eminently the variety found in corrugated schistose rocks, and their formation may be illustrated by the accompanying sketches. In figure 3 the schists are represented in vertical cross-section. If we imagine that by reason of earth movements, *e.g.* in the nipping in of a fold of Keewatin between two bosses of granite or gneiss, there is a downward motion on one side, the schists naturally yield along the lines of weakness presented by the schistic cleavage. The folds that fitted together perfectly in the beginning do not now coincide; they touch at opposing points and leave spaces where outward curves come opposite to one another. The result is a series of cavities, opening and pinching again as they are followed downward. Such veins then are fissures formed by the faulting of corrugated schists parallel to the cleavage. Their horizontal cross section is usually very much like the vertical section in figure 3, perhaps because of some lateral motion of the rock masses; but often there are several more or less parallel veins, and not infrequently as one runs out along the strike another overlapping vein begins. Figure 4 illustrates this arrangement. Where the schist is greatly folded and contorted the veins enclosed by them share the contortions and take on quite fantastic forms, as in figure 5, which is a sketch from location K191, between Wild Potato lake and Little Turtle river. Bedded veins sometimes have quite distinct walls with slickensided surfaces, but generally are much less definite in this respect than true fissure veins.

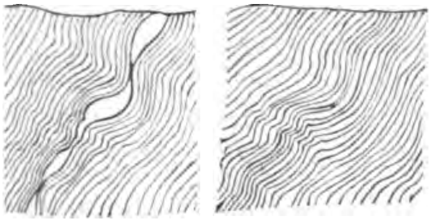
Fig. 3. Origin of bedded veins.

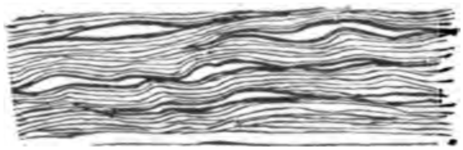
Fig. 4. Overlapping arrangements of bedded veins.

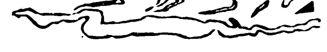
Fig. 5. Arrangements of veins in contorted schists.

The term "segregated" frequently used for these ore deposits seems less correct than "bedded," since it implies a mode of formation by lateral secretion or segregation which is by no means proved. In fact it is probable that these veins are filled with mineral matter very much as fissure veins are.

The lack of regularity and continuity in bedded veins makes them in general less valuable as ore deposits than the more uniform fissure veins; nevertheless in most gold regions they are the usual form of vein and are mined at a profit.

Fissure veins are characteristic of massive rocks, and bedded ores of schistose rocks.

So far as my observations go, true fissure veins, crossing the strike of the country rock, are rarely found in the Keewatin schists, and when found are unimportant in size. The massive diabases interbedded with the schists sometimes contain comparatively small fissure veins filled with quartz. The Couchiching gray schists sometimes have large and well defined fissure veins, as on Goose island, and the granites likewise. It is of course clear that a bedded vein can rarely be found in a massive rock, like diabase or granite, since they seldom present even a trace of schistose structure or bedding planes between which the vein might be enclosed. True fissure veins then are characteristic of massive rocks, as bedded ones are of schistose rocks. The best examples of fissure veins with distinct walls showing slickensides, etc., in this region are to be found between Shoal and Bad Vermilion lakes.

Fahlbands.

Fahlbands, that is, bands of schist impregnated with iron pyrites and other sulphides, occur in various parts of the region, as on Nickel and Pipestone lakes. In other mining countries, such as the Kongsberg silver mining district in Norway, such fahlbands are scarcely rich enough to work as ores themselves, but the veins intersecting them are greatly enriched at these points. For this reason it may be of importance to look for veins crossing fahlbands in the Rainy Lake region.

Segregations and stockworks.

Two other varieties of ore deposits are represented in the region, segregations of ore in eruptive rocks, and stockworks. The magnetite deposits on Seine bay appear to be segregations on the margins of diabase masses, probably resembling those so well described by Vogt in Scandinavia and Dr. Adams in Canada.[21] Stockworks, or rock masses penetrated by a network of minute veins, occur on the north shore of Elbow lake, at the eastern end of the Rainy Lake country. Whether any such deposits will turn out to be of workable value is yet to be proved.

Dr. Lawson's advice to prospectors regarding the district

Dr. Lawson in his report, written several years before the discovery of gold on Rainy lake, states that "the economic value of the Rainy Lake region, as regards its mineral resources, is entirely prospective. There are no mines in the region, and extremely little search has been as yet made for mineral deposits. It is however quite probable that where such search is made the various minerals will be found which are more or less common elsewhere under the same conditions as those which obtain here. The Keewatin rocks of the Rainy Lake region are the same as those in which the gold of the Lake of the Woods occurs."[22] He further says "the Laurentian rocks of the region are, so far as they are known, perfectly destitute of metalliferous deposits, except in one instance, where, at the immediate contact of these rocks with the schists of the Couchiching at the Bear's Passage, a quartz vein occurs in which flakes of molybdenite are common . . . This remarkable barrenness of the Laurentian rocks, as contrasted with those of the upper Archæan, is a fact of great interest as well as of practical importance to the prospector. On the map accompanying this report the distribution of the Keewatin rocks is mapped distinctly, so that prospectors for gold, or iron, or any other of the metalliferous ores, need not waste time examining the Laurentian country."[23]

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[21] On the Igneous Origin of certain Ore Deposits, Frank Adams, Can. Min. Eng. Review, p. 8, Jan. 18, 1894.

[22] Can. Geol. Sur., 1887, p. 180 F.

Dr. Lawson's advice has been followed, and most prospectors have one of his maps in their outfit, and pay special attention to the strips marked green on the map. The advice given is quite natural, for in many of the world's gold regions the auriferous quartz veins are found in similar green chloritic schists; however there is a little risk of overlooking deposits which do not come in either formation, but, for instance, in the eruptives which break through them. An example is to be found in the interesting Bad Vermilion veins, which occur in eruptive granite.

not always safe to follow.

In our field work we made it a point to visit all locations where any work had been done, and in general to traverse as much of the Keewatin bands as possible. Specimens for assay were taken from likely veins which we encountered, not only in the Keewatin but also in the Couchiching and Laurentian. The results will be mentioned hereafter. In reporting on the field work of the summer only those portions of the region presenting some point of interest will be referred to in detail; other portions will be described in a general way, or not referred to at all.

LITTLE AMERICAN MINE.

Location of the Little American.

The first point studied was the Little American mine two miles south of the boundary, on a small island in Minnesota. It lies about a mile west of the new town of Rainy Lake city, which came into existence chiefly because of this and other discoveries of gold in the neighborhood. The first visit was on June 25th. The island consists of green Keewatin schist with a strike of about 60° west of north and a dip of 82° to 85° toward the south. Numerous small bedded veins of quartz occur—flattened, elongated rods or elongated masses with lenticular cross section. The largest vein, on which excavation was going on, appeared to be 2 or 3 feet wide, with several minor veins parallel to it. Mr. Hildreth, who was in charge of the work, says that the vein was 8 feet wide from wall to wall where he sank upon it, but included some "slate," (green chloritic schist). The work done up to this time was really quarrying, forming an irregular opening said to be about 45 feet deep, the lower part being cut off by planking at about 20 feet depth. The richest quartz is rusty and more or less vesicular near the surface, but a foot or two below one finds unweathered sulphides. The quartz is bluish gray, massive looking, contains iron and copper pyrites and a little white calcite, and is not unlike some of the quartz from the Sultana mine near Rat Portage. Mr. Hildreth proved to us by panning that both the oxidized and unweathered ore contained a considerable amount of free gold. He stated that the vein had been traced across another small island to the mainland.

Character of the ore,

The work was carried on in quite a primitive way, hoisting being done with a hand windlass; and it seemed rash to erect a stamp mill, as had been done at Rainy Lake city on the eastern side of the channel, before much more development work had been done. To found a "city" on the basis of this and other prospects in the vicinity seemed still more rash, but it is to be hoped that it will be justified by the future progress of the region.

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[23] Can. Geol. Sur., 1887, p. 181 F.

and its value as shown by a mill run.

On July 19th a second visit was made especially to see the stamp mill, which had started work a few days before. It is a fairly well equipped five-stamp mill, the stamps weighing 850 lb., and dropping 7 inches. It was reported that about 30 tons of ore had been passed through the mill in 48 hours with $512 worth of gold as a result; so that the ore ran about $17 per ton of free milling gold. The concentrates were said to amount to about one-twelfth of the ore, and to have a value of $120 to $300 per ton, which equals $10 to $25 additional per ton of ore crushed, or $27.

The location of the mill on the mainland nearly a mile away from the mine was determined, as I was informed, by a bonus granted by Rainy Lake city. This necessitates the transport of the ore on scows to the mill, adding considerably to the expense of handling. The cost of the whole plant was said to be less than $21,000, including $10,000 as the price of the mine. The freight on machinery, etc., amounted to about $700.

From a Preliminary Report on the Rainy Lake Gold Region, published by Mr. H. V. Winchell and Dr. U. S. Grant, members of the staff of the Minnesota Geological Survey, the following extracts are taken, showing the history of the venture since the time of our visit:

Winchell and Grant's history of the venture.

"This mill began stamping on July 16th, 1894, and continued with some interruption until Sept. 24th of the same year, when, having used all the ore in stock and finding the cost of the operation too great, it was shut down. Shortly afterwards the operation of the mine and mill passed into other hands and plans were laid for work on a more systematic basis." After condemning the lack of business ability shown in the management of the mine and mill, the report quotes Mr. A. S. Chase, one of the directors of the Bevier Mining Company as follows: "From the best information I have the mill ran in all fifty-two days. The nearest estimate as to the quantity of ore crushed is 500 tons. We have no record of each clean up, but the actual shipments of bullion were: August 10th, $362.30; August 20th, $1,058.85; September 18th, $2,481.76; October 18th, $732.42; total $4,635.33. The cost as near as we can tell was about $7 per ton for mining and milling. With proper management it can doubtless be mined and milled for $3 per ton. We have but five stamps and of course the cost of milling would necessarily be large, but there are other reasons for the great cost of producing this bullion which can be easily overcome. The mill produced all the way from 8 to 27 ounces of bullion per day, showing very clearly that quantities of rock were crushed which, with proper sorting, would not have been used, especially with this little mill. It is certain that there was no attempt at deception, and I am fully convinced that gold in largely paying quantities exists in the Rainy Lake region."[24]

Several other claims have been taken up on the Minnesota side of the boundary, but not enough work had been done on any of them at the time of our visit to warrant a careful examination.

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[24] Part III of the Twenty-third Annual Report, Geol. and Nat. Hist. Survey of Minnesota, Jan. 1895, p. 78, etc.

LOCATIONS ON THE ONTARIO SIDE.

Sand Point City.

North of the boundary many claims have been located and some of them paid for, showing the belief of their owners that they were of value. They almost all show small bedded veins in the green schists, perhaps the most promising being an islet southeast of Sand Point island, not far from the inchoate Sand Point "City" with its half dozen log houses. Owing to the unusually high water on Rainy lake, the islet was half submerged, and so far as could be seen little development work had been done. The country rock is of the usual green schists, with a band of less schistose rock which proves on microscopic examination to be a quartz biotite diorite. As vein matter we found, besides quartz, often rusty and porous and sometimes showing a speck of free gold, iron and copper pyrites in considerable amount, the latter weathering into malachite on the surface.

In the Couchiching formation.

Several claims have been surveyed farther north in the Couchiching, and on the north side of Goose island several distinct fissure veins occur, the first of any size that we had seen in the region. The strike of the brownish-gray mica schist is about east and west, while the largest quartz vein, 3 feet wide, strikes nearly north and south. The quartz is however white and barren looking, and an assay made of material taken from one of the veins showed no gold.

A barren belt of Keewatin.

An irregular group of Laurentian exposures separates this stretch of Huronian from a parallel one to the north, running from Redgut bay westwards to the northern arm of Rainy lake. Grassy Portage and other bays give access to the center of this Keewatin belt, which includes much of the two new townships surveyed last summer, Halkirk to the east, and Watten to the west. This strip of Keewatin is unusually free from veins, and very few locations have been taken up upon it except on the shores of Nickel lake, between Rice and Grassy Portage bays, a small sheet of water not marked on the Rainy Lake sheet. These locations are upon beds of iron pyrites, apparently not nickeliferous, nor, judging from a single assay, auriferous.

Locations on Seine bay.

A number of locations have been taken up on the north shore of Seine bay, in the green Keewatin, including many quartz veins of the bedded type, but apparently none of great importance. Some of these locations were taken up a number of years ago for iron rather than gold. The iron ores of the region will be discussed later.

THE SEINE RIVER DISTRICT.

On Grassy, Bad Vermilion and Shoal lakes.

The Seine River district, including several lake expansions, is the portion of the Rainy Lake region now attracting most attention. At the time of our visit no development work of any importance had been done, and there were few signs of the rush that has since covered the ground between Bad Vermilion and Shoal lake with surveyors' lines and stakes.

Paddling up Seine river one passes through a reedy lake expansion, Grassy lake, where the waters of Bad Vermilion lake empty through a small river with two or three falls. Where Shoal lake begins to open out one passes several gold locations, among them on the northwest side of Shoal lake are AL76, and just to the north AL75, where the Wiegand brothers made the first important gold discoveries. When we visited them

The Wiegand location

on July 10th a few men were at work opening upon a vein of quartz ten inches to a foot wide, on location AL75. The country rock, which was supposed to be gabbro as indicated on the geological map, was evidently a very siliceous variety of granite, and further examination showed that a small area of granite reaches from the shore of Shoal lake, where there is a small outcrop, northwards for an undetermined distance, and includes all the veins on the Wiegand property. This rock is rather coarse grained, greenish or flesh-colored, and greatly weathered. It differs from the granite shown on the geological map on the shores and islands of Bad Vermilion lake, being coarser in grain, more siliceous and not so white in color. Microscopic examination of slides made from our hand specimens prove the rock to be granite, or possibly, since there is a considerable amount of striated felspar, quartz diorite. The rock will be discussed more at length in the petrographical part of this report. The report of Messrs. Winchell and Grant, which has been received since our sections were examined and described, confirms the opinion just given, but mentions a somewhat schistose variety of the rock which we did not observe.[25]

in a newly discovered area of granite or quartz diorite.

Gold bearing veins of the location.

The veins on AL75, which Mr. Wiegand kindly took us round to see, are four in number, the largest about five feet in width and striking north and south. The ten-inch vein on which they were sinking strikes 6° or 8° east of north and is not far from vertical. The blasting was being carried on at a point where a cross vein striking 36° south of east joins it. The latter runs out in about 100 yards, but the four main veins striking approximately north and south are very continuous, one according to Mr. Wiegand having been followed for a mile. We found these deposits to be true fissure veins with clean walls, often lined with a gray slaty selvage, which under the microscope has the characters of sericite schist. The quartz from the blasting was rusty and "good looking," containing some free gold, pyrite and galena, the latter mineral having the reputation in the region of being a good sign of gold. In the gold bearing specimens which we obtained the metal is sometimes enclosed in solid quartz, as in some of the quartz from the Sultana mine, and so is thoroughly free milling. It is probable however that another portion of the gold is contained in the sulphides and will prove more refractory. A sample showing no free gold, assayed in the laboratory of the School of Practical Science, yielded a little over $10 per ton. In the opinion of Dr. Burwash and myself, these veins were by far the most promising seen in the region.

Since our visit many more gold-bearing veins have been discovered, and a considerable amount of development work has been done on some of them, as will be seen from the following quotation from Winchell and Grant's report.[26]

Winchell and Grant's report on the location.

"Thomas Wiegand and Alex. Lockhart discovered auriferous quartz veins on this (AL75) and adjoining locations in September, 1893. . . . The country rock immediately surrounding the veins . . . is not inaptly called 'bastard granite' by some of the explorers of the region. This rock has often a foliation which corresponds in general with the strike of the schistose rocks which lie south of Shoal lake. . . In connection with Col. S. W. Ray of Port Arthur, Ont., Mr. Wiegand has done considerable exploring on these locations in the way of uncovering the veins and sinking test pits. Pit No. 1 was 12 feet deep at the lode, showing the vein to increase in width from about 6 inches at the surface to 20 or 24 inches at the bottom, with a vertical dip. Near the top of the ground the vein is banded pink, red and white; but the quartz is all light colored at the depth of 12 feet, and appears to be nearly equally charged with 'sulphurets' throughout. Where stringers of quartz join the vein from the walls considerable free gold is said to have been noticed."

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[25] Part III., 23rd Annual Report, Geol. Sur. Minn., p. 58.

[26] Ibid. p, 81, etc.

The authors of the report go on to describe pit No. 2, 12 feet deep, on location AL94, a sample of which assayed $48 in gold; and pit No. 3 on AL75, which was 19 feet deep, on a vein from 1 foot to 3½ feet wide and growing wider as depth is attained. Two samples of this assayed $7.25 and $66.86 respectively. Of the veins in general they say: "The walls of these veins are smooth and sharply defined, being usually separated from the vein matter by a thin sheet of soft material, supposed to be the product of pressure, shearing and chemical alteration. . . . The mineral content of the different veins varies considerably. Thus vein No. 3 on Wiegand's location is more heavily charged with blende, pyrite, galena and chalcopyrite than veins No. 1 and No. 2, but is no more richly 'mineralized' than some veins seen elsewhere in this same immediate vicinity."

The Lucky Coon and Mosher properties.

They also describe "The Lucky Coon," location 655 P, north of the eastern end of Shoal lake, and east of Bad Vermilion. "The country rock here is quite similar to that at Wiegand's; but the granite is coarser and more massive, and has pink felspar crystals developed in it at a short distance from the veins." This property is owned by Americans. "The vein has a width of about 6 feet and has good walls. It is banded or 'crustified' and contains considerable pyrite, chalcopyrite, blende and a dark mineral resembling argentite. This vein has been traced for more than half a mile by surface outcroppings." Ore from this and another vein on the property assayed $2 and $43 per ton. The Mosher properties, AL110, AL111 and AL112, are referred to as showing free gold. The veins are in the same rock as the two previous properties, and one of them is 6 feet wide.

Since the writing of the report from which extracts have been made a post office has been established on Shoal lake, a stamp mill has been brought in for the Hillyer or Lucky Coon mine, and the sinking of shafts has been begun on various properties; so that probably another summer will show a lively mining camp in full blast. Of course none of the work done hitherto can be looked on as more than prospecting, and until much more development has taken place the real value of this very promising district will not be settled.

Locations on Wild Potato lake.

About five miles above Shoal lake the Seine opens out into Wild Potato lake, the shores of which are largely occupied by an Indian reserve, 23A. Two miles north of the western end of the reserve, and just south of Little Turtle river, are two locations from which rich gold specimens are said to have come, K190 and K191. The country rock is very fine grained and schistose, and of a light purplish to greenish-gray color. A microscopic examination shows that it is a schistose felsite, so that though colored green on the geological map it probably belongs rather to the acid upper series of the Keewatin than to the usual basic variety. The veins, which are very numerous but not very large, strike parallel to the schists, about north 75° east, and are of the bedded variety.[27] The opening, made by blasting, is only 3 feet deep and does not disclose any one distinct vein, but rather a network of veins. The quartz looks rich, and where unweathered contains pyrite, chalcopyrite, with a little malachite and galena. Quartz from this vein which I have seen crushed and panned showed many colors of gold; but too little work has been done to warrant any definite statement as to the value of the property.

A series of locations has been taken up between Seine bay and the north end of Bad Vermilion lake, in the Keewatin schist, and a band of gabbro that runs along the northwest shore of the lake. Some of these were visited, but nothing of special interest was observed.

ON THE UPPER SEINE WATERS.

Between Seine bay and Bad Vermilion lake.

Several gold discoveries have been made farther east, above Sturgeon Falls, the head of steamboat navigation on Seine river. It was intended to visit these in September by way of Lac des Milles Lacs and the Atik-okan river, but low water on the river and serious forest fires, which made the portages almost impassable, prevented the carrying out of this plan. Handsome specimens of native gold come from Harold lake, where the Wiley Brothers of Port Arthur have locations. An assay of a specimen from that locality given by them showed $165 per ton. Gold has also been found near the Atik-okan iron deposits, at Osinawe lake, and at Partridge lake east of Lac des Milles Lacs. The last deposit is described as having been found in 1872 by Mr. Archibald McKellar. Free gold has been obtained here, and specimens of ore which assayed from 1 to 1½ ounces of gold per ton, as reported in The Mineral Resources of Ontario.[28] This location was visited by the present writer on August 31st. A small island in the lake, where some blasting has been done, consists of greenish-gray graywacke and some chloritic schist, no doubt Keewatin in age. In this were bedded quartz veins, sometimes 3 feet wide, striking about north 30° east, and with nearly vertical dip. The quartz is white, sometimes saccharine in look and sometimes rusty, and contains few sulphides. On the adjoining mainland the same vein, or a parallel one, can be traced for 80 or 100 feet, with a width of from 2 to 4 feet. The quartz is white, with few sulphides, like that of the island, but the country rock is a rather coarse-grained, greenish rock, which under the microscope appears to be quartz diorite, or possibly a granite rich in plagioclase felspar. It reminds one

Locations on Harold, Osinawe, and Partridge lakes.

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[27] See illustration, p. 51, which is from K191.

[28] Report of the Royal Commission on the Mineral Resources of Ontario, Toronto, 1890, p. 26.

slightly of some of the Shoal lake granite, but is probably interbedded with the Keewatin schists. The work done on Partridge lake is not sufficient to give any certain idea of the value of the deposits.

Extent of the Keewatin schists.

From what has just been written it will be seen that the Keewatin extends almost due east for about 100 miles beyond the Little American mine, along Rainy lake and the valley of the Seine and its tributaries; and that gold bearing veins occur in it from point to point along almost the whole distance.

Veins in the Laurentian, near Redgut village and at Bear's passage.

Thus far only those veins which occur in the Keewatin or the associated eruptives have been referred to. It remains to mention one or two veins found in the Laurentian. The first, at the narrows three or four miles east of Redgut village on the Indian reservation, contained "good looking" quartz in dark syenitic gneiss; a second is an irregular mass of quartz in gneiss near the village, probably a bedded vein. The quartz contains galena, pyrite, etc., and looks promising. Neither gave any gold when assayed. A third point where veins are observed is on the east side of the Bear's passage. Here there are many irregular veins of quartz which is reddened with iron oxides. Pyrite also occurs in considerable amount, and the vein matter looks very promising in spite of its occurring in Laurentian granite or perhaps granitoid gneiss, but here again the results of an assay were negative.

GENERAL CHARACTER OF THE VEINS AND ORES.

Gold bearing veins in the Keewatin schists,

There was an opinion commonly expressed last summer among prospectors that the gold deposits of the Rainy Lake and Seine district were to be found along certain definite lines or horizons, and that one could find a certain continuity in the gold bearing series of veins. This seems to be true however in a very general way only. The southern portion of the green Keewatin schists, stretching as a long band from the Little American eastward up the Seine and Atik-okan, seems to be more auriferous than other parts of the Keewatin of the Rainy Lake district; but when one comes down to particulars one finds that up to the present no one auriferous horizon can be traced for any great distance. The Little American series of bedded veins on the southern side of the southern band of Keewatin cannot be followed very far. The Little Canada veins belong to the north side of the same Keewatin band. The rich Shoal lake veins run in a contrary direction and are of a totally different kind, since here eruptive granite and gabbro interrupt the continuity of the Keewatin. Farther east the gold bearing veins of K190 and K191, just south of Little Turtle river, are on the north side of the Keewatin band, and in a felsitic rock quite different from the green schists where the gold occurs toward the west. The Partridge lake gold deposits, while in an extension of the same general direction, occur in still another variety of Keewatin, greenish-gray, graywacke and interbedded quartz diorite.

in eruptive granite,

and in felsitic rock.

Assays of ores from the district.

Twenty assays were made in the Laboratory of the School of Practical Science of ores from more or less promising looking veins in various country rocks of the Rainy Lake and Seine River districts. These were chosen so as to cover the ground as generally as possible. From bedded veins in the Keewatin 12 assays were made; 8 gave no result and 4 ran from a trace to 8 ounces of gold per ton. Care was taken to select specimens showing no visible gold. If specimens showing free gold were counted as favorable assays, the results would be 6 containing gold out of 14 altogether. Assays were made of ores from three veins in the Couchiching, all with negative results; and the same is true of three specimens from veins in Laurentian rocks. Out of two assays of ore from fissure veins in the eruptive granite at Shoal lake, one gave $10 in gold and another nothing. Specimens from one of these veins containing visible nuggets would of course have run very high in gold. The results of these assays are given, not with the idea of settling the value of the different parts of the region, but merely to give a general basis for comparison of the different formations as ore carriers. It is of course well understood that a single fire assay is a most unreliable test of a gold bearing vein. Unless a number are made and averaged, and unless the ore is very carefully sampled, the results of fire assays for gold may be very misleading. The only satisfactory test is a mill run of fairly selected ore.

EXAMINATION OF THE NORTHERN PART OF THE RAINY LAKE REGION.

The Pipestone and Manitou country.

After examining the portion of Keewatin running east and west along the eastern arm of Rainy lake and the Seine and its tributaries, it was decided to go north and explore the Pipestone and Manitou country, then attracting some attention. Apparently little prospecting has been done in the irregular and rather inaccessible strip of Keewatin reaching from Redgut bay northwest to lake Manitou; and the long stretch mapped as Keewatin along Rainy river is mostly covered with thick alluvial deposits, so as to be out of reach. The Pipestone and Manitou are however easily reached and lie in the heart of a wide band of Keewatin.

Lake Despair.

Instead of taking the usual Manitou route directly north from Rainy lake we turned off to the west into Northwest bay, and then over lake Hope into lake Despair. The western end of the latter body of water cuts across a narrow strip of Keewatin schists, in which some quartz veins were observed, but not very promising in appearance. A number of white veins of granite (or gneiss) seen from a little distance were deceptively like quartz veins. No blazes or other marks of prospectors were seen.

Clearwater lake.

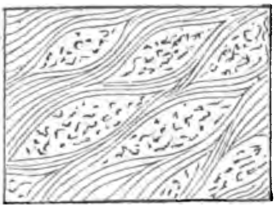
Fig. 6. Agglomerate. Clearwater lake.

Clearwater lake lies mostly within a wider band of Keewatin, and was more carefully studied. Here and there strips of the green hornblende schists of the Keewatin were observed, but acid pale gray felsite schists are more common, and some agglomerates, or rocks formed of masses of coarse quartz porphyry tailing out in fine grained greenish schist, are found. An assay of rather barren looking quartz from a vein in these agglomerates yielded nothing. The acid eruptives of this lake seem to contain few veins, and those of an unpromising kind. Near the upper end of the lake some true fissure veins from 5 inches to 2 feet wide are found, but their contents seem almost free from metallic minerals. Panorama and Burnt lakes to the west of Clearwater are in the green Keewatin, but their shores as far as observed present only unimportant veins of quartz. First Quill, Narrow and Link lakes, which lie between Clearwater and Pipestone lakes, are enclosed in Keewatin rocks, both schistose and massive, containing, especially when schistose, bedded veins and stringers of rather white quartz. An assay of material from First Quill lake gave no gold.

Pipestone lake.

Pipestone lake, with the exception of two bays on the western side near the lower end, where a small area of granite crops out, lies wholly within the Keewatin. It is a comparatively large lake full of intricate channels, such as "The Gates Ajar Narrows," varying in their directions to correspond with the varying strike of the schists. The lower end, running about northeast and southwest, is enclosed in green schists; the upper, almost at right angles to it, is bordered by altered quartz porphyries and soft glossy gray schists and slates. A number of claims have been staked on the lower part of the Pipestone, though none had been surveyed, so far as we observed. A considerable number of quartz veins show themselves in the softer green schists, a few of them fissure veins, but the harder schists and massive diabases contain very few. No bodies of quartz of any size were observed near the granite boss to the west, which is probably not eruptive; Lawson colors it as Laurentian. It differs very much from the Shoal lake granite, being much less siliceous. Along the shores of a deep bay opening toward the west, about 6 miles up the lake, a number of small and a few large quartz veins are seen, but the quartz is ominously white. Higher up the lake several claims have been staked on islands, generally including more or less promising looking quartz veins; but in one or two cases the attraction seemed to be thick beds of pyritous schists which become brown and rotten when weathered. At a point on James bay there are large quantities of such soft rusty schists heavily charged with pyrites, which may properly be called a fahlband. Fresher portions from underneath the gossan are fine grained, pale green, and filled with small striated cubes of pyrite. An assay of some of this material gave a trace of gold. A sample of coarser grained green schist with much pyrites and some stringers of quartz yielded about $2 of gold. As these mineralized beds of schist occur in considerable amounts toward the middle of the lake it is possible they might pay to work for themselves, and if quartz veins should be found in these fahlbands they will probably turn out richer than elsewhere.

Mineralized beds of schist.

Lake Helena.

A small lake about 2½ miles long, unmarked on the map, was found just west of the central part of Pipestone, and named lake Helena. It lies also in the Keewatin, and its shores present a few quartz veins much like those of the larger lake. The nearly east and west upper part of Pipestone lake and Schist lake, both in the felsite schists of the upper Keewatin, were barren so far as we observed. A considerable deposit of pyrrhotite at Stonedam portage, and the pipestone or steatite from which the lake gets its name, will be referred to later. On the whole the central portion of the lake appeared more promising than anything we had seen since leaving the Seine.

Yoke, Sucker and Furlonge lakes.

Yoke lake to the northeast of Pipestone lies in pale green hard schist, mapped by Lawson among the acid series, and seems almost devoid of veins of any description. Sucker lake showed no signs of ore deposits, nor did Furlonge lake, which was reached by means of a hopelessly shallow weed-filled creek. We were surprised to find the large peninsula to the south of that lake made up of coarse grained granitoid gneiss and fine grained red granite, instead of green Keewatin schist as indicated on the map ; however the shores of the lake present very few outcrops, and those of a kind so low and vegetation-covered as to be easily passed over.

From Strawberry to Manitou lake.

Strawberry lake and the two small lakes between it and Missus lake to the east are enclosed mainly by the more siliceous upper Keewatin, and displayed no veins that looked promising. Instead of going east to lake Manitou via Missus, Harris, Sairy Gamp and other lakes redolent of Dickens, we struck south from the second lake east of Strawberry, made a long portage to Cross lake not shown on the maps, and then by another rather long portage reached the lower end of lake Manitou. Cross lake, which is about three miles long, is enclosed chiefly with green Keewatin rocks holding a few veins of white quartz.

A great fault.

Pickerel lake, which is just south of the lower end of Manitou, from which it is separated only by a short rapid down which canoes can run, turned out to be very barren of veins, as however might have been expected from the fact that its shores consist mainly of soft gray slates and felsites, except where the rocks are interrupted by two bosses of granite. At the outlet to this lake through Cedar narrows there is a profound fault, which Lawson estimates at 2,000 feet in a horizontal direction.[29] It is a surprise to find so little fissuring where there must have been so great a disturbance, but no quartz veins were observed in the vicinity.

MANITOU LAKE.

General description of the lake.

Manitou lake is, after Rainy lake, the largest body of water in the region, measuring about 30 miles in length by 6 in greatest breadth, and running northeast and southwest. It is one of the most beautiful lakes of the system, having clear water and great variety of shore ; and its contour is so complicated by reason of deep bays and channels that its coast-line measures more than 160 miles, without taking smaller indentations into account. Two comparatively large bodies of water are connected by a narrow river-like portion, and from the southern end of the southwestern expansion a narrow arm stretches eight or ten miles further southwest to Pickerel rapids, by which its waters are discharged into Pickerel lake and thus into Rainy lake. For convenience we shall refer to the large expansion just above the southwestern arm as the Lower Manitou, and to the expansion at the upper end as the Upper Manitou. The whole of the lake lies within a wide band of Keewatin, with the exception of a few bays on the northeast side of Lower Manitou. Unfortunately the sheet of the geological map covering the Manitou is not yet published, and no really satisfactory topographical map exists, though tracings from the map in the Crown Lands Department of Ontario cover the portions that have been surveyed.

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[29] Report on Rainy Lake Region, p. 33 F.

Southwest end of Lower Manitou.

The southwest end of Lower Manitou and some adjoining lakes will be taken up first. A claim has been staked just east of Pickerel rapids on bedded quartz veins, in rock indicated on Lawson's map as soft glossy gray schists and slates. The material from the veins is "good looking," consisting of rusty quartz, with a considerable amount of iron pyrites and galena, the latter mineral being considered a tolerably sure indication of the presence of free gold. An assay of some of this quartz gave less than two dollars' worth of gold per ton. So far as was observed the body of ore is not large. This is the only instance that turned up of gold-bearing quartz in the "soft gray schists and slates." At this point the direction of the lake as well as the strike of the schists is about east and west; but about four miles east of Pickerel rapids the schists are of the green variety and strike northeast and southwest, while the lake bends toward the same direction, northeast. A tangle of long narrow bays and lakes lies just to the southeast, mainly in the green Keewatin, but their shores present few quartz veins, and none were seen that require particular notice.

Dog Fly lake.

The largest of the tributary lakes, Dog Fly lake, lies between the green schists and eruptives and very striking schist conglomerates, in which both enclosed masses and the ground mass are of green or gray schist. But one small white quartz vein was observed on its shores.

Caribou lake.

A granite area.

Caribou lake, just north of Dog Fly lake, is represented on the geological map as having the same relations to the Keewatin, but we found between it and Manitou a considerable boss of granite, probably occupying two or three square miles, and just showing on the shore of a small bay east of Manitou lake. It is probable that this was forest covered ten years ago, when the survey was made, so that the rounded, reddish hills could not be seen; but at present one can recognize them as granite from a distance. The rock is coarse grained, and at its edges seems to have fused with the green Keewatin, forming a somewhat darker colored schistose rock containing much hornblende as well as orthoclase, but very little quartz; according to its composition, syenite. This granite burst through the schist, since it has carried off fragments of it, and hence is of later age than the Keewatin. No quartz veins were seen in the granite, which is less quartzose than that of Shoal lake.

Lower Manitou.

Four or five miles northeast of this granite boss lake Manitou widens greatly, and has stretches of open water several miles long, though the upper end of Lower Manitou is filled with large and small islands. There are several mining locations on this portion of the lake, which is beyond the limits of the Rainy Lake sheet of the geological survey. The southeastern shore is wholly of green schist, mixed with ash beds or greywackes and conglomerates of the Keewatin. It presents no special points of interest, except some beds of schist, with quartz very heavily charged with pyrite. The main bed is about five feet thick, but assay showed no gold in the pyrite from this fahlband. On the southwest end of this part of the lake there are several bays two or three miles long. The shores of the most southerly one are of

Syenite.

greywackes, with some green schist, sometimes containing white crystals of plagioclase an inch in diameter. Several large irregular masses of white quartz were observed here, and one or two veins of good looking quartz, in one case containing copper pyrites and a little malachite. An assay of the latter gave a trace of gold. In the two long bays to the north of this, one finds hard gray green schists which have quite a remarkable cleavage into board-like slabs. When weathered and lying tumbled together they sometimes look like a heap of cordwood or logs. The most northerly of the three deep bays projecting from the southwest end of this expansion of the Manitou ends in porphyritic syenite gneiss, the *augengneiss* of the Germans, a characteristically Laurentian rock. The dip of the schists becomes very low, not more than 30°, just before one reaches the gneiss. Turning to the upper end of the Lower Manitou, the large islands filling this part of the lake consist of greywackes and conglomerates, with some green schists, all Keewatin. They contain some bedded quartz veins and some large, irregular masses of quartz, one specially promising. A bed of whitish felsite has been staked as a claim, but it is very doubtful if it contains gold. It may have been taken for a quartz vein.

Mineral locations.

An eruptive felsite dyke.

At the northwest corner of Lower Manitou the shores are formed once more of syenite, so that it is evident the Laurentian extends from southwest to northeast a short distance from the shore. A little east of this at a point on the north end of Lower Manitou two locations have been surveyed, 166P and 167P. The rock at 166P consists of dark hornblende schist, green hornblende chlorite schist and flesh-colored felsite schist, all interbedded. Large quartz veins, one six feet wide, occur at this point, containing very rusty ore with a considerable amount of pyrite. The specimen assayed however contained no gold, though the quartz looks as though it should. A little to the east of this several locations have been surveyed on moderately large quartz veins of a more or less promising appearance. A location has been taken also just as one turns to the northeast out of Lower Manitou on a true fissure vein five or six feet wide in places, and traceable at least 100 yards. This is in diorite schist like that found at 166P. There are several other large veins near by, but the quartz looks rather white. On the way up the river-like stretch leading to Upper Manitou the rocks are chiefly of the characteristic green Keewatin, containing at a few points bedded quartz veins very much like those on Rainy lake; but some large masses of hard, tough greywacke and schist conglomerate are found also. Just before the entrance to the Upper Manitou a dyke of yellow felsite schist crosses the green hornblende schists, so that the felsite is, in this case at least, a true eruptive rock of later age than the green schist. This case will be further described in the petrographical part of the report.

Upper Manitou.

The majority of the locations on the Manitou are on its upper part, and as some of them are of great interest this part of the lake will be described with some detail. This sheet of water is nearly ten miles from end to end, and has the usual northeast and southwest trend. It should in reality have a name of its own as a separate lake, for a very narrow though short channel with a stiff current connects it with the rest of the straggling body of water called lake Manitou. The entrance to the Upper Manitou is quite masked with points and islands and might easily be missed altogether, and on several of the older maps this upper expansion is not indicated at all. A large part of Upper Manitou is filled with islands, and there are no long stretches of open water. A number of the islands have been surveyed as gold locations, on one of them, 150P, containing a considerable number of bedded veins and irregular masses of quartz, a little blasting has been done. One of the veins is five or six feet wide and good looking. The quartz is very rusty, contains iron and copper pyrites, and is interbedded with a country rock of greywacke and diorite. If the quartz of this island turns out to be even moderately auriferous the ease of mining and the large quantities exposed would make it very profitable to work. However, the result of two assays from this location was negative. A shaft about 25 feet deep has been sunk in the middle of the island. On the mainland adjacent there is a vein of mixed quartz and felsite eight or ten feet in width, greywacke being the country rock. Gold locations in and near the lake. 150P.

Location 131P, comprising a point, almost an island, at the southeast end of Upper Manitou, was one of the earliest locations taken up by the well-known prospector LaCourse. The weathered surface of the quartz was exceedingly rich in gold, and very handsome specimens are shown, reputed to have come from it. A small amount of development work has been done on the lake shore, the rock having been blasted out to a depth of twelve or fifteen feet, but at present there is no indication of a vein, either bedded or fissure, in the hole blasted out. The quartz from the surface is very rusty and cellular; but lower down it is white and glassy, with many cubes of pyrite and portions of other sulphides. An assay of this ore gave $186 of gold per ton, by far the best result in the Manitou country. The adjoining rock contains some green schist, but consists chiefly of a fine grained gray mica schist or gneiss, which has not at all the look of a Keewatin rock; on the contrary, it appears something like Couchiching. As however this rock is found only at this southwest corner of the lake, and all the rest of the shore is distinctly Keewatin, it may perhaps be looked on as a Keewatin rock considerably modified in the neighborhood of the Laurentian; for the latter formation must lie only a short distance to the west, judging by the strike of the schists and the outcrops found on the north end of Lower Manitou, four or five miles to the southwest. I am informed by Mr. Rochon that there is another vein several feet wide on the other side of 131P, on which no work has been done, but which is much more promising than the one described. Just north of this location a vein of white quartz four feet wide occurs in similar mica schist or gneiss; but here and there green Keewatin is interbedded with the gray schist. 131P.

Farther to the northwest, on the shore of the lake, diorite and hornblende schists and massive green diabase appear, evidently rocks of Keewatin age; and here and there in them one finds bedded quartz veins as well as a few fissure veins, on which no claims have been staked. The Keewatin schists are of the hard hornblendic kind usually found near the contact with the

Laurentian. Still farther northeast bands of felsite are intermixed with the green Keewatin and a few small, almost horizontal, veins of quartz occur.

133P.

At the time of our visit, the middle of August, there was only one location on which work was being done, 133P, near the northeast end of Upper Manitou and a mile north of the entrance. Here Mr. Rochon, of the firm Lillin and Rochon from Keewatin, had a small party engaged in the development of a bedded vein of quartz charged with sulphides. The thickness of pure quartz was about 1½ feet, but the width of schist intermixed with quartz was much greater. A half-pound of the ore crushed in a mortar and panned afforded a number of colors of gold, and a nice specimen of free gold was taken out during our visit. They had gone down to a depth of about 12 feet, and the country rock, which is variable, consisted of a hard, fine grained, pale greenish felsite schist. Not far off the ordinary green Keewatin schist was found. Some other veins of rather rich looking quartz were pointed out by Mr. Rochon, who stated his intention of testing them later. The quartz from this opening differs a good deal from that found elsewhere in the region. It is white and mixed with flesh colored felspar with yellowish chlorite or serpentine, and cubes of pyrite sometimes a third of an inch through. At times the serpentine shows the polishing and striation of slickensides, indicating faulting when the vein fissure was opened. The location 155P, including the short rapid forming the mouth of Upper Manitou, belongs also to Lillin and Rochon, and contains quartz veins similar to that now being developed. Near the channel some good examples of brecciated vein matter were found. A large island southwest of 133P consists of schist conglomerate, ordinary green schist and felsite schist, with some very large masses of quartz, chiefly white and barren looking.

155P.

Promise of the Manitou region.

Up to the present Manitou lake has yielded only specimens, some of them exceedingly fine however. There is no mine and no stamp mill on its shores and the deepest exploration at the time of our examination in the middle of August did not go down more than 25 feet. Ten assays in all were made of ore from various claims and locations on the lake, with the result that four contained gold running from a trace to $186 per ton. Some specimens from deposits having a very favorable appearance gave no gold on assay, though this of course may have been an accident, and the locations showing the largest bodies of ore made the poorest showing in this respect. By far the richest of all, LaCourse's, seems to lie just at the contact of Keewatin and Laurentian. One gold bearing specimen was obtained from the southwest end of the lake, another from the lower expansion, and the other two from the Upper Manitou; the latter portion of the lake affording by far the richest specimens and having on its shores and islands perhaps nine-tenths of the locations which have been taken up.

Means of access to the Manitou lakes.

What the ultimate value of this portion of the region will be can only be guessed at, until very much more development work has been done; and that can hardly be expected until the means of communication are greatly improved. At present the only means of access is the canoe in summer and a dog train in winter. Two canoe routes are available, one from Rainy lake on the south, requiring a long day's paddle; and a somewhat shorter one from the Canadian Pacific at Wabigoon. In distance the latter route is much the shorter, the upper end of Manitou lake being only 20 miles in a straight line from Wabigoon station; but in time there is less difference, since there are six portages, some of them long, and one of them troublesome from muskege. At the time we passed through the water was low, lengthening one of the portages seriously; and the wild rice had grown so tall and dense at the narrows near the upper end of Little Wabigoon that we lost much time in forcing our canoe through it. That portion of the lake was in fact a great harvest field loaded with grain, and having a few inches of water at the foot of the stalks. The Ontario Government intends, I believe, to cut a wagon road from the northeast end of Manitou to a small lake six or seven miles to the north, the head of navigation on the Wabigoon chain of lakes. It is expected that small stern wheel steamers will be able to make their way up to this point. At the time we followed the route this hardly seemed possible, so crooked and shallow was the river, and so dense the growth of rice and other water plants at the Little Wabigoon narrows; however, in high water no doubt the water ways are much more passable.

LAKE WABIGOON.

From Manitou to Wabigoon.

The shores of the small chain of lakes between Manitou and Wabigoon consist, as far as observed, of green and grayish green Keewatin; and the same appears to be true of the western and southern shores of the two portions of Wabigoon lake. The strike of the schists on the southeastern body of water was observed to be about north and south, and the dip nearly vertical at the Indian village; but on the south shore of the larger east and west stretch of the lake the strike is approximately east and west. It is evident that the band of Keewatin reaching up toward the northeast from Pickerel lake, along the line of Manitou lake, turns north at Little Wabigoon and sweeps to the west along the shore of the greater Wabigoon, on its way to complete another mesh of Huronian, enclosing a large area of Laurentian. There is one interesting location on lake Wabigoon, Oliver Daunais' Wabigoon mine, about four miles southeast of Barclay station on the Canadian Pacific Railway. A shaft 65 feet deep has been sunk near a small lake south of the larger one, and a small house built. At the time of my visit all was deserted and the shaft half full of water. Several openings had been made at other points near the shaft. The ore is white quartz, often enclosing much gray or brownish rock matter as a breccia, and also copper and iron pyrites. Grayish schist from the walls is often more or less filled with cubes of iron pyrites. The veins appear to be of the usual irregular bedded type, and the country rock is either schistose or apparently massive. An assay of the ore gave about $3 per ton in gold.

Course of the Keewatin band.

Wabigoon mine location.

SOME ORE DEPOSITS IN THE LAKE OF THE WOODS REGION.

Relations of ore bodies to enclosing country rock.

For the sake of comparison several mines and prospects near Rat Portage and Rossland were visited, special attention being paid to the country rocks enclosing gold bearing veins. In regard to the mines themselves nothing need be said, since a good account of them is given by Mr. Blue, Director of the Bureau, in his Report for 1893. Several of the more important mines were described ten years ago by Mr. Coste,[30] but of course many new deposits have been discovered since. Mr. Blue collected a large number of specimens of both ores and country rock, and these were afterwards submitted to the present writer for determination; but the study of an isolated piece of rock is so much less satisfactory than a study of the same in connection with its stratigraphical relations that it seemed useful to go over a portion of the ground again. In the present report the relations of the ore bodies to the enclosing country rock will be briefly described, other points being neglected.

Sultana mine.

One naturally begins with the Sultana mine on the island of the same name, up to the present almost the only steady producer of gold in the province. Here we find the ore to be quartzite, enclosed as bedded veins with a nearly vertical dip in chloritic and hornblendic schist of Keewatin age. The general appearance of both quartz and schist reminds one of those of the Little America and other ore deposits on Rainy lake, though none of the latter show quite the same very fine grained quartzite structure of the quartz. The Sultana is close to the edge of the Laurentian, which is here a gray, coarse-grained, granitoid gneiss, showing little foliation, very like some gneisses of the Rainy lake region.

Ophir Jack mine.

A short distance to the south, on the same island, is the Ophir Jack mine, wholly enclosed in gneiss, and apparently a true fissure vein. The Ophir Jack, which is really only a prospect hole, never having been worked in a business-like way, has produced many exceedingly fine specimens of nuggets in quartz, and the ore is quite different in aspect from that of the neighboring Sultana, since the quartz is white and more massive. With the vein quartz on the dump portions of dark chloritic and micaceous schists are found, quite different in appearance from the country rock of the Sultana mine, and unlike any rock seen in the vicinity.

Gold Hill and Black Jack mines.

A few miles southeast of the Sultana a number of mines have been more or less opened up; of these the Gold Hill and Black Jack were examined. At the former mine there is a true fissure vein of white quartz, with some sulphides in a gray green, massive looking country rock, which under the microscope appears to consist mainly of hornblende, replacing a weathered augite, so that it is probably a much decayed diabase, one of the igneous beds of the Keewatin. Around the Black Jack mine one finds fine grained, massive diabase and green chloritic and hornblendic schist, both quite like Keewatin rocks from Rainy lake. A band of diorite porphyrite, speckled with white porphyritic crystals of striated felspar, which occurs near by, may perhaps be compared with the porphyritic green schists sometimes found near the Laurentian of Rainy lake.

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[30] Geol. Sur., Can, Report of Progress, 1882-83-84, Part K.

The Rossland region. Several interesting mining locations were visited near Rossland. a station on the Canadian Pacific just east of Rat Portage. Lawson's map of the Lake of the Woods includes this part of the country in the Laurentian, describing the rocks as merging into ordinary gneisses, though they are "coarsely crystalline basic rocks, composed largely of triclinic felspar, hornblende and biotite, with a little bluish quartz."[31] The region turned out to be much more varied than had been expected, for typical Laurentian rocks are intermingled with others having the character of the Keewatin.

Bad mine. The Bad mine, scarcely more than a prospect hole, is specially interesting geologically. It is sunk upon a bedded vein striking about southeast and northwest and dipping 50° or 60° to the southwest, containing white or pink quartz, with iron and copper pyrites, galena and much free gold in small scales and nuggets. It took but a few minutes to gather from the dump a number of specimens showing the yellow metal. Below the vein one finds a coarse grained biotite syenite gneiss, gray in color, and just above it a rather fine-grained red granite or granitoid gneiss, forming a bed 10 or 15 feet in thickness. Above the red layer there is the usual coarse grained gray gneiss of the region. Both rocks have a thoroughly Laurentian appearance, and the bedded gold bearing vein seems to be a contact deposit. The gold appears here entirely dissociated from the Keewatin or Huronian, the only marked instance of the kind that I have observed in the region. It is possible however that the red granite is a dyke of later age, and corresponds to the siliceous granite near Shoal lake, which it resembles in being very siliceous and in containing an unusual amount of plagioclase. Under the microscope the rock shows evident signs of having undergone crushing.

D98, Norway, Treasure and El Diver. Near by, on location D98, the writer saw gold obtained by panning material taken from a vein of felsite in black hornblende schist, no doubt both belonging to the Keewatin. Some sulphides and glassy black quartz were associated with the felsite, and probably carried the gold; but there was no distinct quartz vein. Neighboring locations are the Norway mine in hard green schist near granitoid gneiss, and the Treasure mine, where gold bearing quartz veins are connected with felsite bands in gneiss, probably belonging to the Laurentian. Some distance to the north, near the shore of Island lake, is the El Diver mine, where small quartz veins occur in green hornblende schist and also in the adjacent syenitic gneiss.

Peculiarities of Lake of the Woods region. Almost all the gold locations visited by the writer in the Lake of the Woods region appear to lie along the disturbed margin of the Laurentian and Keewatin; gold bearing veins, both bedded and true fissures, occurring within the Laurentian gneisses as well as the Keewatin schists, as though they partook more or less of the nature of contact deposits. If the gneiss is really a species of plutonic rock which has heaved up, fissured and folded the already solidified Keewatin, the occurrence of veins along and near the contact seems very natural, for those convulsions must have opened up many channels for the flow of water, highly heated by the molten or half-molten rock beneath, the very conditions favorable to the deposit of ores. In this respect the

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[31] Note on maps published with the report on the geology of the Lake of the Woods region, 1885.

Lake of the Woods gold region seems to differ greatly from that of Rainy lake, where scarcely any important gold bearing veins have been found near the edge of the Laurentian, and none whatever within the Laurentian The important Shoal lake veins occur near the contact of granite and Keewatin, but the granite seems to have no connection with the Laurentian.

GENERAL CONCLUSIONS.

Characteristics of gold bearing rocks in the Rainy Lake region.

In summing up the results of the summer's work, one may say that gold has been proved to exist at many points in the region explored, but always in rocks of Huronian or Keewatin age, or in eruptives bursting through them, never in undoubted Laurentian; a point of difference from the Lake of the Woods region, where the association of gold bearing veins with the Laurentian gneisses is not uncommon. The gray mica schists and gneisses of the Couchiching, underlying the Keewatin so extensively in the southern part of the region, have not as yet been shown to contain gold. The suggestion of Lawson, then, regarding the probably auriferous character of the Keewatin is borne out by the results of prospectors' work up to the present. The rocks of the Keewatin vary greatly in character, some being soft or hard green schists with interbedded massive greenstones, others greenish gray fragmental rocks, and still others yellowish or reddish siliceous rocks, felsite schists, derived from quartz porphyries. Gold is found most frequently in the softer green schists, but also at times in the fragmentals and the felsite schists. The massive greenstones seem rarely if at all auriferous, and the same appears to be true of the coarser conglomerates and agglomerates. In the Rainy Lake—Seine region proper—the Keewatin schists do not appear to be more auriferous near the contact of the Laurentian gneisses than elsewhere; but the richest gold bearing quartz of the Upper Manitou occurs at the greatly altered margin of the Keewatin. The eruptive masses of granite in the region have been proved to be auriferous in only one case, near Shoal lake, and here the adjoining eruptive mass of gabbro, or rather anorthosite, may have been the determining cause; though, so far as the writer is aware, no gold bearing veins have been found in the anorthosite itself. Winchell and Grant say that "perhaps the most favorable feature of the veins of this particular portion of the Rainy Lake district is their intimate relation with the areas of the eruptive rock called 'gabbro' on the north and of greenstone on the south. . . . It is not clearly proven that the veins date from the advent of the gabbro; but the fact that the gabbro seems to be later than the peculiar granite area lying between Shoal and Bad Vermilion lakes, and the further fact that the veins are quite different in strike from the other veins around Rainy lake, and appear to radiate from the gabbro area as a center, is strongly indicative that the formation of the fissures was due to the irruption of the gabbro.'[32] Lawson holds however that the gabbro is earlier in date than the granite.[33] Which authority is correct the writer cannot attempt to decide, since the region at the time of his visit was quite undeveloped and was not studied with reference to the time relationships of the eruptive rocks.

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[32] Part III. 23rd An. Rep. Minn. Geol. Sur p. 85 and 86.

[33] Rep. on Rainy Lake Region, An. Rep. Can. Geol. Sur.. 1887, p. 57F.

The gold bearing veins are generally of the bedded or segregated variety in the Keewatin schists, though true fissure veins are not absent. In the granite the gold is found in true fissure veins only.

Minerals associated with gold.

The minerals associated with the Rainy Lake gold are those usually found in other gold regions, and the country rock enclosing the veins is like that of many important goldfields. The gold of the Black Hills in South Dakota occurs in fahlbands and in bedded quartz veins in slates and schists of Archaean age,[34] that of the Southern States occurs in bedded quartz veins in metamorphic slates, talcose schists, etc., of late Archæan or early Palæozoic age, with numerous associated diabase dykes;[35] that of Australia is found partly in bedded veins and partly in fissure veins in palæozoic rocks;[36] the gold of California occurs in deposits of various kinds enclosed in "almost every kind of crystalline rock known, including the eruptive and metamorphic series, exclusive however of the two extreme types of acid and basic rocks, viz., the obsidians, vitrophyres and other glassy rocks on one side, and the ultra basic rocks, gabbros, norites and basalts on the other." Mr. W. H. Storms, M.E., from whose paper on the Wall Rocks of California Gold Mines the foregoing sentence is taken, states that "a great many veins in California are wholly within the granite, and these in the aggregate have produced a large amount of gold."[37] There is nothing therefore either in the associated minerals or the rocks enclosing the veins to suggest that the gold deposits of the Rainy Lake region will not equal in productiveness those of other mining regions. Up to the present however all that has been done has been of the nature of prospecting, and it would be rash to make confident assertions regarding the future of a region where the deepest mine is not yet down 100 feet, and only one five-stamp mill has been at work, and that for only a few months. Thus far one is justified in saying that the prospects are good for many of the locations on bedded veins in the Keewatin schists, and especially bright for the fissure veins in granite at Shoal lake, which are probably the most promising gold deposits in Ontario.

Large extent of the gold field.

During the summer gold claims and locations were examined from Pipestone lake on the west to Partridge lake on the east, a distance of over 100 miles, and from the Little America mine on the south shore of Rainy lake to the Wabigoon mine, 70 miles to the north. The gold deposits of the Lake of the Woods region come within 50 miles of Pipestone lake, and it is not unlikely that gold will be found in the intervening Keewatin schists, which have hitherto been little explored. Gold was found years ago at the Huronian mine and various points on the Shebandowan to the east of the region examined, and has been discovered recently near Ignace to the north of the Canadian Pacific. There is no reason to suppose that the many bands of Keewatin rock to the north of the present region will not prove auriferous when carefully explored. Grouping the Lake of the Woods region with that of Rainy lake and adjoining lakes and rivers to the north and east, we have a gold field 200 miles in length, from the Lake of the Woods to lake Shebandowan, and 70 miles in width, from Rainy Lake City to Wabigoon or Ignace. Of course much of this great area is barren Laurentian, but probably one-third is Huronian and worthy of the attention of prospectors.

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[34] Kemp, Ore Deposits of the U.S., p. 217.
[35] Ibid., p. 252.
[36] Phillips, Ore Deposits, p. 463 and p. 475.
[37] Engineering and Mining Journal, Feb. 23, 1895, p. 172.

Conditions in favor of the field.

When it is remembered that this gold field is not in the heart of Africa, nor in an Australian desert, nor in remote valleys of the Rocky mountains, where access is difficult, but in the most populous province of Canada, and touching at its southern edge the enterprising state of Minnesota, it seems as though its value should quickly be proved; and if it be really as productive as present appearances indicate, a year or two should see the development of a prosperous mining community. As to physical conditions, the region has everything in its favor, plenty of good water and several fine waterpowers, a large amount of still unburned timber for building and mining purposes, a wide area of the best unoccupied farming land in America close at hand to supply the necessary food products, and a climate which is admirable in summer, somewhat rigorous in winter, but always thoroughly healthy. No part of the region is more than 60 or 70 miles from a railway, and steamboat communication is available in many parts. If the district is proved to be of importance, lying as it does between two of the most enterprising cities of the continent, Duluth and Winnipeg, it will speedily have all the railway accommodation needed.

Cause of the absence of placer gold.

There is one serious drawback as a gold mining region, a drawback shared by the rest of eastern North America, in that no placer mines have been or are likely to be discovered. It is true that a few surface deposits due to the weathering of gold bearing veins have yielded gold on panning, and that there are reports of the auriferous character of some alluvial deposits on Shoal lake; but the almost clean sweep made by the glaciers of the Ice Age has probably removed the sands and gravels that might have afforded placer gold and mixed them with overwhelming amounts of barren drift. That the absence of placers however does not always seriously hamper the development of a gold region is proved by South Africa, which bids fair soon to be the greatest gold producing country in the world, though none of its mines are placers.

Mistakes that should be shunned.

In the development of this new Ontarian gold region it is to be hoped that the errors which have brought failure in other parts of the province will be avoided. Every new gold field presents new conditions and must be looked on as an experiment until the methods best suited to the treatment of its ores have been determined. We have already proved in Ontario that there is a danger in new inventions in the way of reduction plants, no matter how attractive they may appear in the glowing descriptions of interested agents. One who is tempted in this way should, before buying, make a visit to the rusting failures to be seen at most of the mines near Rat Portage, where thousands of dollars have been squandered on useless inventions, and where the only working plant is an orthodox stamp mill. Up to the present however, there seems to be no tendency in the Rainy Lake region to experiment with novelties, since all the mills talked of are stamp mills. But there is another error into which many of the enterprising property owners of the district seem in danger of falling, that of spending money on a stamp mill before sufficient exploratory work is done. Until a mine has been so far developed as to disclose bodies of ore sufficient to pay for the mill itself, there is serious risk in investing in one. If, as the report goes, three stamp mills have been brought into the Seine country this winter, it is to be feared that too little development work has been done to assure success, and a failure which may cast doubt on the whole region is not impossible. Probably many of the bedded veins of the Keewatin, while carrying comparatively rich ore, will prove too small to pay for the erection of a stamp mill; and doubtless some mistakes will be made, and some losses incurred on this account. It is greatly to be desired that custom mills should be built at convenient points within easy reach by water of the mines on the Rainy lake and Seine river, as well as on the Manitou. In well equipped modern mills of fair size the work ought to be done far more economically than in small five-stamp mills like that at Rainy Lake City, where the cost of milling, $7 per ton, seems quite excessive. Such mills have worked very successfully in the western states, and should prove a boon to miners in a small way in the Rainy Lake region, since their properties could thus be thoroughly tested without the heavy expense and risk of putting up a stamp mill; and in many cases it would probably pay better to sell the ore than to mill it on the property.

Utility of custom mills.

OTHER ECONOMIC MINERALS OF THE RAINY LAKE REGION.

While the gold of Rainy lake is at present by far its most valuable asset, there seems little doubt that at some time several other economic minerals may prove of importance, and during our summer's work everything of the kind which lay in our way was briefly examined. Lawson in his report, so often quoted from, says:

"Deposits of iron may confidently be looked for. Indeed on Seine river good indications of iron ore have already been discovered, and further up the river, beyond the limits of the region mapped, valuable deposits have been found on the Atik-okan. Iron pyrites, copper pyrites and arsenical pyrites are very common in small quantities in the Keewatin rocks, and will doubtless some day be found in valuable deposits in some portion of the belt. Lead and zinc ores may also possibly be discovered. The occurrence of bosses of serpentine suggests the possibility of diamonds, and some enterprising prospector may yet be rewarded for a close examination of the vicinity of the serpentine rocks indicated on the map, or of others that may be discovered, particularly if they be found near the carbonaceous schists that sometimes occur in the Keewatin. Asbestos should also be carefully searched for in these serpentine rocks. Poor varieties were observed in veins in the serpentine of Clearwater lake. Closer inspection may reveal the finer and more valuable varieties. Good soapstone is not uncommon in the Keewatin rocks, and will some day be of value. Some of the siliceous schists would make good whetstones, and the finer textured felsite schists good hones. The development of these varied resources will however only come with the gradual settlement of the country,

Lawson's list of certain and possible minerals.

as it is only the discovery of the more valuable metals in large quantities that will create a sudden influx of prospectors and mining population."

Diamonds. All of the minerals referred to in the above quotation undoubtedly occur in the Rainy Lake region, with the probable exception of diamonds. That even they are present in small numbers is by no means impossible. Diamonds of good quality, though few in number, have been found in the glacial deposits of Wisconsin; and it is suggested that they came originally from the vicinity of Pigeon river, on the boundary of Ontario,[39] so that there probably are diamondiferous rocks in the province. It may be doubted however if another Du Toit's Pan or Kimberly is likely to be found in western Ontario. Nor is there any evidence up to the present that zinc or lead or copper ores exist in important amounts in the region, though they are all associated with the gold quartz to a greater or less extent. Arsenical pyrites was seldom observed by us, but no doubt exists in small quantities, as in the neighboring Lake of the Woods region. Iron pyrites is found in quantities that may prove important in the future on the shores of Nickel lake, between Grassy portage and Rice bays.

Iron pyrites. On 577P and 580P under a thick gossan of brown iron ore one finds masses of solid pyrites several square yards in extent and more than a foot in thickness. As little or no stripping has been done, one can hardly form an idea of the extent of these deposits. The mineral exists as a rather coarse granular mass in which the usual cubes may be seen. As it is common iron pyrites, and not pyrrhotite, the name "Nickel" lake is misleading, and it is probable that the locations were taken up there under a misapprehension. An assay of this pyrite showed no gold.

Pyrrhotite. Pyrrhotite, or magnetic pyrites, occurs however in the region, and specimens were obtained from the Stonedam portage, on the east side of Pipestone lake, where a deposit of this mineral 10 feet wide is interbedded with the schist. No copper pyrites was observed with it, a point in which it differs from the Sudbury pyrrhotites; but the results of an assay showed only 0.16 per cent. of nickel, though specimens from a greater depth might give better results, as often happens with nickel ores. The rock with which it is associated is a very rusty Keewatin schist.

Cobalt bloom. At the southeast corner of the Bay of Islands, Bad Vermilion lake, a small coating of the rosy erythrite or cobalt bloom was found in a quartz vein. This is the only example of a cobalt mineral obtained in the region. Is it the "Bad Vermilion?"

Magnetic iron ores. The most important of all the ores in the region, except those of gold, are the magnetites, which occur in considerable amounts on Seine bay and in much greater quantities on the Atik-okan, 80 miles to the east. A number of iron locations were taken up on Seine bay several years ago. On 213X, the only one visited by us, masses of tolerably pure magnetite occur in a dark green, coarse grained hornblendic rock, apparently massive. The way in which the ore occurs suggests the variety of segregation out of the magma of a basic eruptive rock described by Vogt in Scandinavia. How extensive these deposits are we did not determine. It is worthy of note that some of the basic rocks of the region contain enough magnetite to make the compass

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[38] Report on the Geol. of the Rainy Lake Region, p. 180 F.
[39] W. H. Hobbs, Am. Geologist, July 1894, p. 31.

useless. This is well illustrated at a point to which my attention was drawn by Mr. T. R. Deacon, O. L. S., between lots 10 and 11, third concession of the township of Halkirk. Mr. Deacon supposed that there must be a considerable mass of iron ore at the spot, since the compass with which he was running a line refused its duty there. We found that the rock itself, a greenish gray schist with disseminated particles of magnetite, had a decided effect on the compass even in small fragments, so that there was no need to suppose a mass of magnetic ore beneath the surface.

The Atik-okan locations.

The most important iron ores yet discovered are on the Atik-okan, a tributary of the Seine coming in from the east near Steep Rock lake. The best known location is that of the McKellars at Iron mountain. This ridge, rising at points more than 100 feet above Atik-okan creek, may be seen by canoe voyagers for a considerable distance as a bare brown cliff. The ridge is comparatively narrow and corresponds to the strike of the gray green Keewatin schist, running a little north of east and south of west, as inferred from the position of the sun, since a compass is there of no use. The dip is nearly vertical. The whole rock is heavily charged with magnetite, and some beds or irregular masses, separated by strips of decomposed schist, are of the pure ore. One body of ore is a natural magnet. Any fragment broken off shows polarity and attracts particles of magnetite. The direction of polarity varies greatly from point to point, as shown by a pocket compass; but the poles seem to point generally east and west parallel to the strike of the ridge. In a transverse opening in the bed it was found that the ore attracts the north pole of the compass on one side and the south pole on the other, both very strongly. However a little experimentation proved that there were local poles toward which the compass was greatly deflected from all sides; and apparently these poles are irregularly arranged. There was no evidence to show that these masses of ores had been magnetized by induction from the earth's magnetism, as is sometimes assumed, for the poles, as shown by the compass, seemed to have no reference to the direction of the meridian. It was discovered a day or two later that the pocket compass used in the experiments had its polarity reversed, the south pole now pointing north.

Judging from the brief examination given to the "Iron Mountain" one may say that there is undoubtedly an immense mass of fairly pure ore, though many parts are somewhat mixed with the green schist and in a few places iron pyrites may be seen. A thin section of the country rock proves that it is an actinolite schist. Mr. Peter McKellar in his evidence before the Royal Commission states that the ore "averages 64 per cent., and lots have been got that will go 70 per cent."[40]

Similar deposits have been found a few miles further down the Atik-okan, where the Wiley Brothers of Port Arthur have done some exploration with a diamond drill. At present of course these iron ores are not available, since they are 30 miles from the nearest point on the Canadian Pacific Railway, in a region approachable only by canoes. Railways built to open up the gold region may however help these ores to a market.

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[40] Report on Min. Resources of Ontario, p. 144.

Soapstone. There are also several non-metallic minerals which will in all probability be of value at some time. Soapstone or steatite of fair quality is found at several points in the Keewatin schists, e. g. at Rock Island bay in Watten township, and near the northern end of Pipestone lake. Up to the present this material has been used only by the Indians for making pipes, which are often very ornamental. The mineral is pale greenish gray, fine grained, and shows scales of talc somewhat mixed with magnetite and dolomite. Little cubes of iron pyrites occur in some specimens. Pure foliated talc has not been observed in the region.

Serpentine and Asbestos. Lawson has called attention to several occurrences of serpentine, as at the south end of lake Despair and the north end of Clearwater lake. This rock is very dark gray and dull in color, so as to have no value as an ornamental stone, but in the outcrop at the north end of Clearwater lake a fibrous variety shows itself, which suggests the possibility of finding chrysotile, or what is usually called asbestos. The specimens obtained at this point are coarsely fibrous and quite brittle, but they may have been injured by the forest fires which have raged along that part of the shore, since the amount of combined water, as determined in our laboratory, is only 12.68 per cent., while the normal percentage of water is about 13.50. It is well known that a slight lowering in the percentage of water is associated with brittle fibre in the famous Thetford district in the province of Quebec, which supplies most of the asbestos of the world.

Muscovite. Another mineral that may be of value is muscovite, white or potash mica, which occurs in the coarse grained dykes of pegmatite penetrating the Laurentian and sometimes also Huronian; though up to the present crystals of large enough dimensions to be useful have not been observed. From the adjoining Lake of the Woods region fairly large sheets of excellent muscovite have been obtained.

Building and ornamental stones. Many of the rocks of the Laurentian would furnish good buiding stone, quite as good as the gneisses quarried near Rat Portage ; and some, like the handsome porphyritic biotite syenite at the lowest rapids on Sand Island river, would furnish fine ornamental stone suitable for monuments, etc. The rich appearance of this rock with its large, deep red felspars in a gray ground could not fail to be striking on a polished surface.

Absence of limestones. One serious lack in the mineral resources of the region should be mentioned, however; that is the almost entire absence of limestones. Lawson mentions the limestone boulders which are numerous in the drift deposits along Rainy river, and have been burned for lime in some instances; but beyond this he refers only to a few impure layers of crystalline limestone, or perhaps rather dolomite, among the green schists on Manitou lake. As the region fills up with settlers this lack will be more or less felt.

Clay and sand. Among the drift and alluvial deposits clay is very common along the river bottoms, and brick are already being manufactured on a small scale. Beds of sand are not common, though shore deposits, like that at Sand Point island, will probably suffice for local needs ; so that all needful building materials except lime will be readily obtained.

STRATIGRAPHY AND PETROGRAPHY OF THE RAINY LAKE REGION.

Study of the rocks.

In the previous portion of this report the economic side of the work has been taken up, and it is now proposed to consider a number of points of more purely scientific interest. No attempt will be made to cover the ground exhaustively, since those desirous of studying the matter in detail may refer to Dr. Lawson's excellent report; but an outline of the subject will be given, and anything of special interest will be discussed at greater length. The rocks will be taken up in ascending order, Laurentian, Couchiching and Keewatin; and the name Laurentian will be retained, although the rocks thus designated have been proved to have consolidated at a later period than the overlying schists. The statements of Lawson regarding the eruptive relationship of the gneisses to the Huronian rocks above have been fully borne out by our investigations in the region; and we must suppose that by the deposit of perhaps ten miles thickness of Couchiching and Keewatin rocks combined,[41] the isogeotherms, or levels of equal temperature, gradually ascended toward their normal distance from the surface; and as a result the once solid Laurentian was brought into a condition of igneo-aqueous fusion, or semi-fusion, welling up at some points, and at others allowing the schists resting upon them to sink into sharp anticlinal folds. That fragments of the solid schists were thus broken loose and floated away, and that apophyses, irregular veins of molten matter, were injected into fissures of the rocks above, anyone may satisfy himself by a day's canoeing among the islands in the eastern part of Rainy lake, where the two formations are in contact.

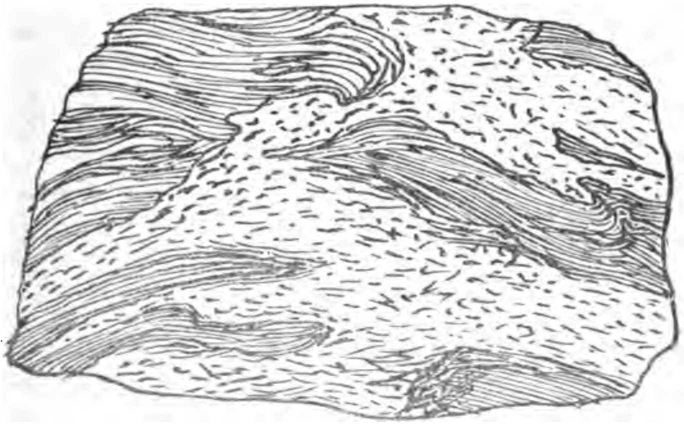

Fig. 7. Contact of Granitoid Gneiss and Couchiching. Goose Island, Rainy lake.

THE LAURENTIAN ROCKS.

Laurentian gneisses of the district,

The Laurentian rocks consist partly of granite and syenite, but chiefly of granitoid gneisses of a composition corresponding to granite, syenite or quartz diorite, having a more or less distinct foliation, parallel as a rule to the strike of the schists enclosing their rounded areas. There are instances however, as on the west side of Bear's passage, where the Laurentian is seen cutting across the schist planes of the Huronian.

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[41] Report on the Geology of the Rainy Lake Region, p. 47 F, 102 F, etc.

and their difference from gneisses of other regions.

It is worthy of note that these gneisses differ greatly from some typica Laurentian gneisses of other regions, e.g., the Thousand Islands, where one finds in many cases great and sharply defined variations of mineral composition, one layer quartzose or pure quartz, another felspathic, a third micaceous or hornblendic, each with little or no gradation into the other, and all folded and contorted. In the Rainy Lake region, so far as observed by the writer, the gneisses have not this character. They sometimes present variations corresponding to the *schlierige structur* of massive rocks, resulting from the action of flow upon a magma having differences of basicity in various portions, or having portions of schist torn off and partially dissolved. The only characteristic examples of gneiss resembling the typical Laurentian of some eastern localities observed by the writer were found along Sand Island river, a few miles below Little Turtle lake. Is this a remnant of original Laurentian gneiss which escaped fusion?

Types of Rainy Lake Laurentian.

There are several types of rock found in the Rainy Lake Laurentian, some granitoid in appearance, others porphyritic. The granitoid rocks are sometimes gray and verge towards quartz diorites, and at others whitish, yellowish or flesh colored. The gray granitic rocks contain usually little quartz, a good deal of orthoclase or microcline, much plagioclase with a small angle of extinction from the twin plane and a distinct zonal structure, and a considerable amount of brown biotite and green hornblende, the latter, as mentioned by Lawson, sometimes having the look of a secondary mineral, and probably representing augite. The felspars have a tendency to idiomorphic form, and sometimes might be called porphyritic. Undulatory extinction and cataclase structure are commonly to be found. These rocks, in spite of their slight foliation, may be classed as massive, and range from plagioclase granites to quartz diorites. To this group belong specimens collected at Fort Frances, Gash Point, Rest island, Angling island, and the very gneissoid rock northeast of Redgut village.

Granitoid gneisses.

The flesh colored or yellowish variety differs from the last in containing more quartz, orthoclase and microcline, less plagioclase, and muscovite, sometimes accompanied by biotite. They are granites proper, or perhaps in some cases aplites. Their felspars have the usual tendency to form porphyritic crystals, and the striated ones show more or less zonal structure. Evidence of the action of crushing or shearing strain is to be found in broken crystals and undulating extinction. Examples have been found near Bear's passage, Gash Point, and on islands in Swell bay. It is possible that these rocks should be looked on as belonging rather to the eruptives than the gneissoid group. They sometimes cut across the schistose structure of the overlying Huronian, as at Bear's passage; and they show few traces of foliation. A rock from the west shore of Pickerel lake, mapped by Lawson as eruptive, has some points of likeness to this group. A specimen of rather dark flesh color from a peninsula on the south shore of Furlonge lake should also be grouped here in all probability, though the micas are too much weathered to be determined, and the quartz is more greatly crushed than in any other sections examined. One example collected on an island (Location 166T) in Swell bay, contains a sharp edged fragment of gray Couchiching schist surrounded by a half inch margin of granite much whiter than the rest. A thin section disclosed no difference in composition in this bleached rim, except the absence of the small amount of biotite and iron oxides found in the rock generally. Some very schistose gneisses from the east shore of Rocky Islet bay turn out to be simply crushed and sheared granites of the type just described. The distinctly porphyritic gneisses also include a darker, more basic series, and a flesh colored, more acid one; in both however the porphyritic appearance is caused by the presence of large crystals of felspar, often Carlsbad twins. These have commonly an oblong or somewhat rounded oblong shape, but may be tailed out at each end, forming *augengneiss.* The size of the porphyritic felspars varies greatly, a half inch being the usual length, the largest observed, about 2½ inches long, occur at the lowest rapid on Sand Island river. The ground mass is generally coarse grained and distinctly schistose; and, as noted by Lawson, the porphyritic felspars usually have their longest diameters in the direction of the schistose structure.

Porphyritic gneisses, and

Under the microscope the darker porphyritic gneisses are found to consist of quartz in rather small amount, orthoclase and microcline, a little plagioclase and biotite or hornblende, sometimes both. The biotite, as Lawson has shown, very commonly weathers to epidote, which forms large yellow crystals. Titanite is a common accessory mineral. The porphyritic felspars, so far as observed, are never ordinary plagioclase, as in the basic variety of the more granitic Laurentian rocks, but often microcline with microperthitic inclusions of albite. Embedded in the microcline one finds many black needles, perhaps rutile, brown rows of dots or scales and long prisms of apatite. In one case a well formed twin of brown hornblende was found completely enclosed in porphyritic microcline. The rim of the porphyritic crystals is irregular, and generally bordered by a layer apparently of crushed quartz and felspar. Frequently, at the very edge of the crystal, the felspar is penetrated by quartz, forming the micropegmatite structure, which in this case seems to be caused by the strains which have acted on the rock.

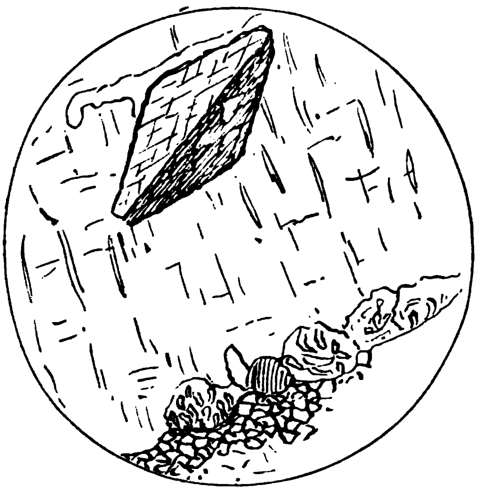

Fig. 8. Microcline containing Hornblende, Micropegmatite on e. gc. Redgut bay.

sequence of events in their structure.

The sequence of events in the history of these porphyritic syenite gneisses seems to include first the crystallization of basic substances as apatite, rutile and sometimes hornblende and biotite; immediately after this, or partly coincidently with it, microcline took crystalline form. Then cooling was accelerated, perhaps by the convulsions accompanying the nipping in of the Huronian and the fissuring and partial dissolving of the overlying schists;

and the other constituents crystallized out, including a second generation of felspars and of the basic minerals. There was probably some motion in the mass before complete solidification, rounding the edges of the porphyritic felspars and allowing the pegmatitic intergrowth. In some cases still further motion of a shearing kind, perhaps after complete consolidation, gave rise to the *augengneiss* structure.

Good examples of these basic porphyritic gneisses are found at the Halfbreed reserve and on Redgut and Rice bays. At some points, e.g., the Halfbreed reserve, the syenitic gneiss is traversed by very fine grained or felsitic looking veins which may be two feet in width. At the reserve the larger veins have a paler selvage along the not very sharply defined edge of the coarse grained rock, and very narrow veins, sometimes not over an inch wide, intersect both. The latter have darker selvages and a structure suggesting a shearing motion of the syenite walls. Under the microscope the fine grained rock is thoroughly granitic in appearance, and differs from the gneiss mainly in having more quartz and less of the basic minerals and no porphyritic felspars. These veins are probably of the kind sometimes called "segregation veins," where the fissures have opened before the complete solidification of the enclosing rock and more siliceous portions of the magma have exuded into them.

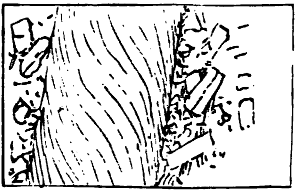

Fig. 9. Vein of very fine grained or felsitic Granite in Porphyrite Syenite Gneiss. Halfbreed Reserve, near Fort Frances.

The flesh colored porphyritic gneisses have in general the same constitution as the syenitic ones, but with different proportions of the more important ingredients, quartz being more abundant and biotite and hornblende much less so. Some examples have a considerable amount of plagioclase of idiomorphic form and zonal structure, thus resembling the flesh colored granites; but the large phenocrysts of microcline distinguish them. Good specimens were obtained on the south shore of Furlonge lake, at the lowest rapids on Sand Island river, and on a bay west of the Lower Manitou lake, the last being a good example of augengneiss.

Other gneisses.

There remain to be considered some gneisses having sharply differentiated layers, suggesting the type of Laurentian familiar in the eastern part of Ontario. The only examples of this kind observed are from Sand Island river, between Little Turtle lake and Redgut bay. Naturally they vary greatly in character, and their peculiarities are better studied in the field than in thin sections under the microscope. There are bands of rather dark gray rock consisting essentially of much orthoclase, a little oligoclase and a large amount of green hornblende. This rock, which is a hornblende syenite gneiss in composition, differs from all the other Laurentian rocks examined in containing no microcline, and showing no zonal structure nor idiomorphic forms in its felspar. Specimens are found not far below the outlet of Little Turtle lake. At no great distance away banded gneiss consisting of very micaceous and very felspathic layers occurs, which under the microscope proves to consist of much quartz, orthoclase and micropegmatite, with a little plagioclase and biotite. At another point a pale gray, almost white gneissoid rock contains bands of quartz, and proves under the microscope to be a much crushed muscovite gneiss. It is made up of quartz, orthoclase, plagioclase and muscovite, with a trace of biotite. Some of the felspar showing no striations occurs as porphyritic crystals, often broken and re-cemented, or with parts drifted a little asunder. These crystals have a marked zonal structure, the center differing in angle of extinction from the exterior, and are probably untwinned plagioclase, since one can hardly imagine orthoclase to have such variations in optical properties. The rock just described is perhaps a very siliceous example of the acid granitic rocks sheared into a gneissoid arrangement, since the "mortar structure" is prevalent and the muscovite probably represents an alteration product of crushed orthoclase.

COUCHICHING ROCKS.

Consistence of the Couchiching schists.

The thick series of schists to which Lawson has given the name Couchiching comprises the oldest rocks of the region, resting upon the later Laurentian gneisses which have torn off fragments of them and sent up apophyses into their fissures; and underlying the series of Keewatin schists and eruptives which Lawson indicates (doubtfully) as Huronian. These monotonous, gray schists consist typically of quartz, sometimes in granular form, and brown biotite with a varying amount of felspar, both orthoclase and plagioclase. They have been somewhat briefly described by Lawson,[42] who looks on them, no doubt correctly, as altered sandy sediments. They show those rapid changes of composition in passing from one layer to another that suggest sedimentation, and in some cases the quartz of which they are so largely composed has a distinctly granular aspect, though in others the quartz particles fit into so perfect a mosaic as to hint at a deposit from solution. These fine grained mica schists and gneisses are so sharply different from the Laurentian rocks beneath that the line of demarcation is usually very distinct; though occasionally, as on Lichen island and others in the eastern arm of Rainy lake, the Laurentian is seemingly interbedded with the Couchiching. This however, as shown by Lawson, is due to the Laurentian magma having forced its way between the layers of schist. The nearest approach to a transition between the Couchiching and Laurentian is to be found on the southeast shores of Rice bay, where the writer found himself in doubt as to the classification, though Lawson maps the region as Couchiching. A specimen from near the point dividing the two arms of Rice bay has a ground of the usual mica schist containing elongated pale yellow portions having dark green nuclei. An examination of a thin section (595) shows that the bleached portions differ from others mainly in the absence of biotite and chlorite, while the dark nucleus consists of chlorite, some muscovite and magnetite. Another specimen from a point not far off has dark green and yellowish layers, the green ones containing some hornblende and epidote as well as biotite, chlorite and quartz A pale green variety contains beside chlorite and biotite cloudy patches of muscovite or sericite. Pale gray, almost white, varieties containing quartz, with some orthoclase and plagioclase and a large amount of muscovite, approach the muscovite gneisses of the Laurentian in character, and examples with only traces of the felspars occur forming muscovite schists. The muscovite gneiss resembles closely some rocks which have been described by the writer among the acid gneisses of the Laurentian, since they contain much microcline and plagioclase having at times distinctly idiomorphic forms They are apparently sheared subporphyritic granites.

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[42] Geol. Sur. Can., 1887, 107 F, etc.

Examples of contact metamorphism.

The occurrence of minerals characteristic of contact metamorphism in some parts of the Couchiching is of interest. Lawson describes certain rounded or stoutly spindle-shaped bodies (occasionally square or rectangular in outline) as consisting of an aggregate of particles of muscovite and kaolin, and as representing weathered andalusite or some allied mineral. He remarks the total absence of felspar in a rock which has undergone contact metamorphism in contact with a granitic mass as an interesting fact, comparing his observations with those of Rosenbusch at Barr-Andlau.[43]

Garnets.

Similar specimens were obtained by the present writer on the north side of Goose island; but the most striking examples were found on islands and the mainland just east of Grassy portage. On one of the islands, in a matrix of granular quartz with a little biotite, there are clusters of well formed wine-red garnets, wrapped round with dark green mica. The garnets have often transparent, doubly refracting inclusions and black grains, apparently of magnetite. On the mainland near by the mica schist is closely crowded with staurolite crystals and very small pale garnets of exquisitely perfect shape. Some of the staurolites are found on examining thin sections to be completely changed to a scaly aggregate like that described by Lawson for andalusite, but the forms of twins crossing at 60° are still distinctly preserved. In other sections the staurolite is fresher and has well defined sections with parallel extinction and strong dichroism, rich amber brown and pale yellow. It is worthy of note however that these examples of "contact of metamorphism" are apparently some distance, at least a mile or two, from the nearest Laurentian; while at many points of immediate contact the mica schist contains none of these minerals, and is seemingly quite unchanged. So far as observed the masses of Couchiching swept off by the Laurentian gneiss show few or no contact effects.

The Couchiching area.

It is probable that the occurrence of Couchiching schists is somewhat wider than has been indicated by Lawson's map; since rocks having the characteristic features of these schists, granular quartz with brown biotite, have been found by the writer in a few localities at some distance from the large Couchiching area. A specimen from the southern shore of the south-eastern end of Clearwater lake, a half-mile from its outlet, in an area mapped as Laurentian, is typically Couchiching in appearance, showing the granular look of the quartz very distinctly in a thin section (672); and the country rock of 131P on the Upper Manitou, in a region not yet mapped by the Geological Survey, seems to be of the same character. Both examples come just at the edge of the Keewatin, as one would expect. It may be that the rock from Clearwater lake corresponds to the micaceous granulitic rock which

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[43] Geol. Sur. Can., 1887, pp. 107 and 108 F.

Lawson has described, from a point half a mile below Burnt narrows on the same lake, as an altered quartz porphyry, though the thin section examined by the writer shows no trace of porphyritic structure.[44]

THE KEEWATIN ROCKS.

Consistence of the Keewatin.

By far the most interesting of the series of rocks represented in the Rainy Lake region is the Keewatin, a series of eruptive and fragmental rocks of great thickness and variety, consisting broadly of a lower group of basic eruptives and volcanic ashes, and an upper acid group. The green schists and beds of massive rock of the lower group rest, so far as the writer has observed, conformably upon the Couchiching. Lawson and Winchell and Grant speak of a certain unconformity between the two as proved by the occurrence of conglomerates near the base of the Keewatin[45]; but the conglomerates appear seldom, if ever, to rest actually upon the Couchiching, and in any case contain no pebbles which can be identified as Couchiching in origin. In several localities, on the other hand, there appear to be transitions between Couchiching and Keewatin; Lawson mentioning the interbedding of the two varieties of schist at some points. Specimens of a wrinkled schist taken by the writer from the junction at the southeast end of Redgut bay seem intermediate in general appearance as well as in microscopic characters between the two series, since the rock is made up chiefly of brown mica and green chlorite, with a little quartz and probably a little felspar. However, the question of conformity or unconformity is not a very important one in this case, for the general character and origin of the two series of rocks, one apparently an ordinary clastic more or less metamorphosed, and the other eruptive and pyroclastic, mark them off by a sufficient break. If the presence of conglomerates alone is to be held as a proof of unconformity, the Keewatin itself must be split up, for conglomerates occur at more than one level in the series.

Lawson has treated the petrography of the Keewatin at considerable length,[46] and it will be unnecessary here to do more than refer to the more salient types of rock and to describe a few specimens of more than usual interest.

Diabases, gabbros and diorites.

The bulk of the lower basic portion of the Keewatin is formed of massive rocks, chiefly diabases, more rarely gabbros, sometimes apparently diorites. Many of them are excessively weathered, the felspars turned into an aggregate of epidote, zoisite, etc., and the augite into secondary hornblende or into chlorite and carbonates. In many cases too they have undergone shearing or crushing forces, so that all gradations may be found between massive, tolerably fresh diabase and aggregates of decomposition products that retain hardly a trace of the original structure of the rock. These changes are graphically described by Lawson, and a number of interesting illustrations given showing the effects of stretching and shattering upon the minerals composing the rock, so that no further account of them is necessary here.

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[44] Geol. Sur. Can., p. 88 F.

[45] Ibid., 1887, p. 38 F and 84 F.

[46] Ibid., p. 57 F, etc.

Porphyroids. A number of rocks having more or less the look of schistose clastics or greywacke turn out to be porphyroids, having a magma of felsitic or microgranitic habit, formed, so far as one can determine in the fresher examples, of minute interlocking felspars with perhaps some quartz and always more or less muscovite, chlorite or biotite. In more weathered ones sharp rhombohedra or irregular patches of dolomite, calcite and chlorite or biotite occur in the ground-mass, and secondary quartz may be found. The porphyritic crystals are sometines, as in a specimen from the northeast corner of Lower Manitou lake, sharp and clean cut, with perfect crystalline outlines and few signs of crushing or weathering; but all stages of decay may be observed until mere clouds of an aggregate of epidote, zoisite, etc., remain. In most cases the crystals are more or less broken or rounded, and they may be drawn out into tails. When not too badly weathered to show twinning, the crystals seem almost invariably to be plagioclase, and the lamellæ have in general an angle of extinction of 8° to 20° from the twin plane, where the twinning is according to the albite law, the average being 14°, indicating a composition between andesite and labradorite. In many cases twin lamellæ according to the pericline law occur also. Good examples of these more or less schistose porphyrites were obtained on the Seine river, on Lower Manitou and Cross lake. In some instances blebs and fairly well formed dihexahedra of quartz occur along with the plagioclase in sufficient amounts to justify calling the rock a quartz porphyrite. Examples were found on Cross lake and on a small island (623P) near Rocky Islet narrows. In the latter case (thin section 648) a crystal shows embayments of the magma. The rather basic character of the porphyritic felspars and also of the magma as shown by the dark color caused by the presence of chlorite or biotite in considerable amounts, and also the presence of large quantities of carbonates in some instances, marks these rocks off from the group of modified quartz porphyries included in the upper acid Keewatin rocks.

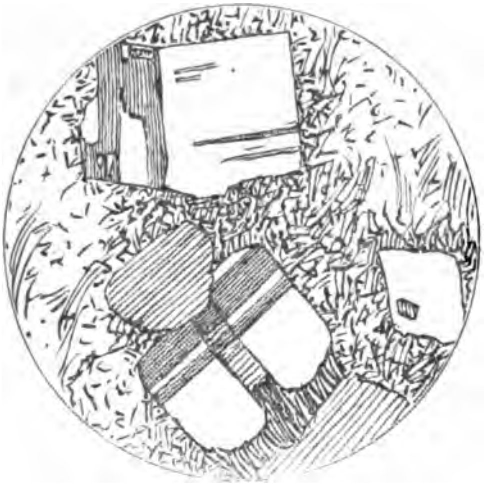

Fig. 10. Quartz Porphyrite. Lower Manitou lake.

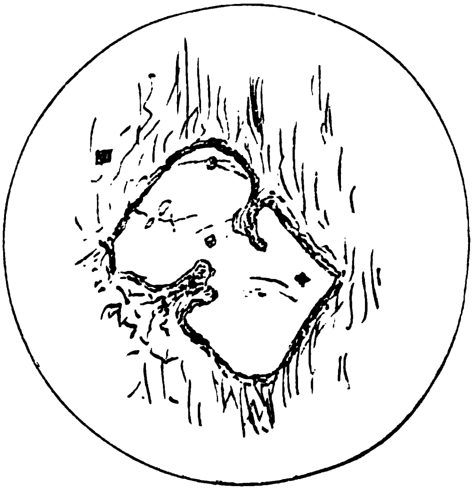

Fig. 11. Quartz Porphyrite. Rocky Narrows.

The schistose members of the basic Keewatin are often interbedded with massive sheets of altered eruptives, and are hard to separate from the more crushed and altered ones. They consist chiefly of hornblende schists near the contact with the Laurentian, and afford an examble of contact alteration, but in other localities of chlorite schists. The specimens obtained from small strips nipped in by the Laurentian, as along Sand Island river, may also contain biotite in important amounts. Thin sections (555 and 627) illustrate this well, consisting as they do almost wholly of pale blue green, faintly dichroic hornblende with scales of brown mica. In other cases, as described by Lawson, we find coarse grained hornblende schists and diorite schists, and also finer grained rocks in which the hornblende is of a fibrous, felted character, with some quartz and calcite.[47]

Hornblende, chlorite and diorite schists.

The chlorite schists have a special interest from their occurrence as the country rock of auriferous bedded veins, as at the Little America mine near Rainy Lake City, where the soft, fissile, lustrous green schist consists of fine scales of chlorite with minute particles, apparently of quartz, and irregularly distributed masses of some carbonate. Black spots of an opaque mineral, probably magnetite, complete the list. In other thin sections magnetite is much more common and shows the usual octrahedral outlines. A specimen of pale green, lustrous schist from Strawberry lake (674) reminds one somewhat in its faintly blotched appearance of *garbenschiefer*. Under the microscope with a low power it is seen to be a sort of agglomerate of paler and greener portions. With a high power both parts are found to consist of the same elements, chlorite and quartz, with a little calcite, but the greener portions contain chlorite in larger amount. In many parts of this section cloudy patches are found to be filled with minute crystals of rutile, often knee and arrowhead shaped twins.

Transitions.

It need hardly be said that transitions between the hornblende and chlorite schists are numerous. There are also paler green schists, as described by Lawson, largely charged with epidote and zoisite, forming links to a set of hard, compact, pale green rocks showing little or no trace of schistose structure and consisting chiefly of epidote and zoisite, usually with some quartz and chlorite. The latter may perhaps be called saussurite rocks, the result probably of the weathering of a basic felspathic ash. Examples of the sort were obtained on Seine bay. Along with the chlorite schists the soapstones may be mentioned. pale gray or bluish gray, slightly schistose rocks, so soft as to be scratched with the nail, used by the Indians as pipestone. Two thin sections were examined, one from the upper end of Pipestone lake (553); another from Rocky Islet bay in Watten township. The former proves under the microscope to consist of scales of talc, a little chlorite, and a considerable quantity of a carbonate, no doubt dolomite, since it does not effervesce with cold acid. Much magnetite is scattered here and there through the rock. The specimen from Rocky Islet bay (552) consists mainly of talc with the characteristic high polarization colors and tendency to rosette structure ; the only other minerals being a little chlorite and a considerable quantity of magnetite, often in small grains arranged in rows outlining areas of talc. It is probable that these

Soapstone.

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[47] Geol. Sur. Can., 1887, p. 73 F., etc.

areas represent the shapes of some original mineral from which both talc and magnetite are derived. The black lines in one case run in two directions nearly at right angles to one another, suggesting perhaps the cleavage of an augite. In another instance they meet at an angle of 114°, suggesting hornblende.

Nondescript schists.

A few rather nondescript schistose rocks may be mentioned here. One of these found in Halkirk township is greenish gray, of medium grain, and so magnetic that the surveyors could not use their compasses in its neighborhood. It is interbedded with green Keewatin schists and diabases. Examined with the microscope (659) it proves to consist of tremolite with a little green hornblende, some biotite having a strong green and brown dichroism, but little difference in absorption in the two directions, much calcite and magnetite. The extinction angle of the colorless hornblende is in one case as high as 26½°, but generally not so high. Another specimen (676), fine grained and dull gray which comes from Nickel lake and forms the country rock of a thick bed of pyrite, has a microgranitic structure and consists chiefly of quartz, a little felspar, chlorite and muscovite. Tattered looking, pale garnets and pyrite occur as accessory minerals. This is the only instance where garnets were found in the Keewatin.

Non-eruptive clastic rocks.

Ordinary clastic rocks not of eruptive origin are of comparatively rare occurrence in the Keewatin, but present considerable variety, since they run from slates and greywackes to conglomerates enclosing boulders, sometimes apparently of Laurentian origin, a foot in diameter. Specimens of slate from the upper end of Pickerel lake and from a railway cutting near Wabigoon were examined, and both appear to consist of quartz, with scales of chlorite, or perhaps sericite, and many black particles probably of carbonaceous matter, in denser clouds at some points than others, but without the definite clear spaces mentioned by Lawson.[48] A specimen obtained from the narrows between Lower and Upper Manitou is slaty in appearance, but spotted with many tiny rhombohedra of calcite. Under the microscope it proves to be composed of chlorite and quartz, as to the ground mass, and to contain many crystals of rutile, but no black particles. It should therefore be placed among the chlorite schists.

Greywackes.

Greywackes from several localities, especially along the Seine river, were examined, but demand no special mention. The country rock of the Partridge mine, on an island in the lake of the same name, appears to be a greywacke, since it consists of unrounded fragments of quartz and calcite in a fine grained paste of chlorite, quartz, etc. It should be mentioned that several rocks taken for greywacke in the field turned out when examined microscopically to be sheared and weathered porphyries or porphyrites in which the crystal form of the felspars was still preserved.

Agglomerates and conglomerates.

Nothing need be added to the description given by Lawson of the agglomerates and conglomerates, though the question of the source of the pebbles of granite, gneiss and quartz porphyry in the latter is an interesting one, since the Laurentian rocks of the region have been proved to be of *later age* than the conglomerates. Probably Lawson's suggestion that they may have come from rocks then solid that were later brought into igneo-aqueous fusion to form the present Laurentian gneisses, is the most probable solution of the problem.[49]

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[48] Geol. Sur. Can., p. 94 F.

ACID KEEWATIN SCHISTS AND PORPHYRIES.

Felsites and quartz porphyries.

The acid group of Keewatin rocks, including mainly felsites or sericite schists and quartz porphyries, appears as a whole to be younger than the green schists and massive rocks of the Keewatin. In most parts of the region there is no indication of unconformity between them, and often the two varieties of schists are more or less interbeded at their contact. In a few instances however there are distinct proofs of a want of conformity. The best illustration of this was found just south of the entry into Upper Manitou lake, on the west shore of the long reach from Lower Manitou. Here a vein of yellow schistose rock about six feet wide cuts across the strike of the green schists and sends apophyses into them. The schistose structure of both rocks is well marked, especially in the green schist, and the direction of cleavage runs with uniformity across the dyke of yellowish rock. Specimens from the dyke show a nacreous lustre on the cleavage surfaces and contain many blebs of quartz. In spite of its well marked schistosity the rock is a typical quartz porphyry, as proved by the examination of a thin section (575). There is a colorless, felsitic ground mass of the usual kind, but crowded with sericite scales having a parallel arrangement. The porphyritic minerals consist of quartz, sometimes dihexagonal pyramids with embayments of the magma, now and then broken and having undulatory extinction; orthoclase, untwinned or as Carlsbad twins; and plagioclase in about equal amount, having an angle of extinction from twin planes ranging from 12° to 18°, and therefore somewhat more acid than labradorite. The felspars usually present sharp crystalline form, but are sometimes broken, and are always considerably weathered. The scales of sericitic do not wrap around the porphyritic crystals, but keep their parallelism and stop short in contact with them. Some masses of a carbonate surrounded by brown oxide of iron are to be found scattered through the ground mass.

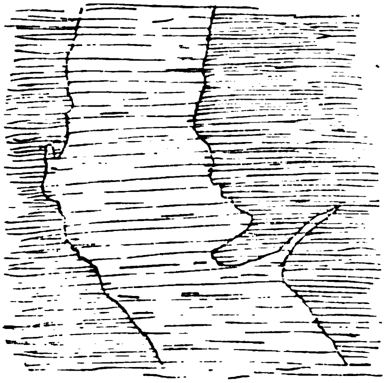

Fig. 12. Eruptive vein of Felsite Schist, 6 feet wide, in Green Schist. Upper Manitou lake.

Not far from the dyke just described there is a bedded vein or dyke of similar rock having in general the same strike as the green schists on each side, but sending off apophyses, showing that it is of irruptive character. It is not so schistose as the last, contains less sericite, and the felspars have succumbed more completely to crushing, while the quartz crystals have often survived almost unhurt. In these two instances it appears that the schistose structure has resulted from pressure pure and simple, since there is no evidence of shearing motion. They also make it clear that, at least in some cases, the schistose structure, and hence the strike of the schists, has nothing to do with an original stratification. The lower Keewatin rocks of Upper Manitou must have been solidified, and have been fissured before these dykes of Upper Keewatin were injected into them. Are these quartz porphyries effusive varieties of the same magma which solidified as gneisses underneath the green Keewatin? Whether or not they have the same origin as the gneisses, they must have been poured out before the final series of convulsions by which the Laurentian nipped in the folds of Keewatin of which the felsites form a part.

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[49] Geol. Sur. Can., p. 85 F.

All gradations exist between quartz porphyries such as those described and felsites or sericitic schists in which the porphyritic crystals have been almost completely destroyed. Some of these schistose rocks may however have been originally felsites devoid or nearly so of the porphyritic structure. Examples occur in which quartz crystals are rare or absent and the prevalent felspars are plagiocalse, thus affording transitions to the quartz porphyrites. When the ground mass includes biotite, and no orthoclase phenocrysts occur, we must call the rock mica porphyrite, as in the case of specimens previously described from the Seine river. The felsite schists and agglomerates have been sufficiently described by Lawson,[50] and will receive no further mention here.

Mica porphyrite.

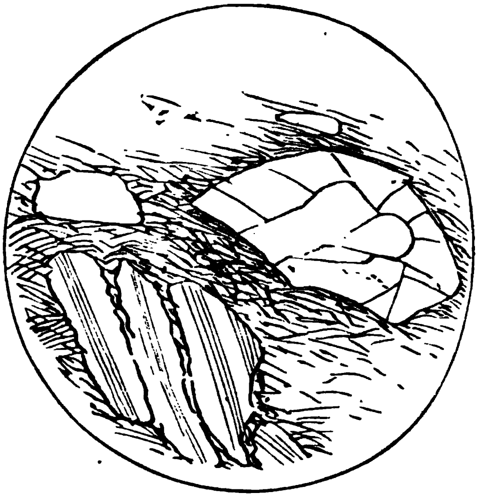

Fig. 13. Deformed basal section of Quartz, showing fine cracks. Clearwater lake.

GRANITE BOSSES.

Granites in Keewatin areas:

At numerous points in the region granite projects through both Laurentian and Huronian as small or large bosses. No examples of granite surrounded by the Laurentian have been studied microscopically by the writer, but considerable attention has been paid to those occurring in areas of Keewatin. Some rather interesting granites, which have been described by Lawson from Pickerel lake,[51] were found to have an unusual relationship of the felspars. In a section from the west shore (620) a first generation of idiomorphic plagioclase, very finely striated (anorthoclase?) and with traces of zonal structures, was followed by the crystallization of microcline and quartz filling in the spaces. Well-formed plagioclases are completely enclosed in large crystals of the later felspar. In a thin section (637) from the east

at Pickerel lake,

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[50] Geol. Sur. Can., p. 85F, etc.
[51] Ibid. p. 145F.

side of the lake it appears as though crystals of finely striated plagioclase had formed a nucleus about which the microcline was deposited in parallel crystallographic position. The outline between the two is sharply drawn, and the microline is quite unweathered, but the plagioclase (or perhaps anorthoclase) contains scales of muscovite parallel to the longest axis of the crystal, and has a number of epidote crystals heaped at its centre.

between Caribou and Manitou lakes,

A boss of granite somewhat different in character was found by the writer covering more than a square mile between Caribou lake and Manitou. It is a coarse-grained, flesh-red rock bordered by a rim of blackish flesh-red, schistose rock where it touches the green Keewatin schists. In thin sections one finds quartz, orthoclase, often with microperthitic inclusions, plagioclase and a little biotite, mostly weathered into chlorite, as the essential minerals; and apatite and titanite as accessories. The plagioclases have narrow twinning, a low angle of extinction from the twin plane, and a tendency to zonal structure. They are at times idiomorphic. All the minerals show traces of strain, and in a thin section from the darker edge, where the boss seems to have mingled with the green schist, there are lines of crushing where nothing is left but an aggregate of particles. The chlorite schist from the contact seems to have suffered no metamorphism, unless the accumulation of black specks, probably of magnetite, in dark streaks and whorls is to be looked on as a result of metamorphism.

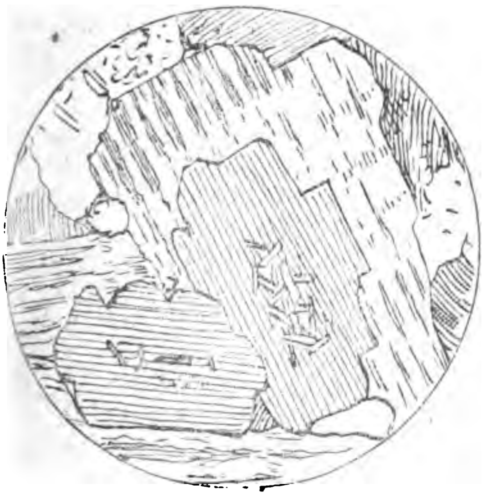

Fig. 14. Microcline enclosing Anorthoclase. Pickerel lake, east side.

and near Shoal and Bad Vermilion lakes.

There is a most interesting region near Shoal and Bad Vermilion lakes, where at least three bosses of granite of irregular shape are associated with anorthosite. These granites are rather coarse-grained and vary in tint from flesh color to a greenish gray. Some of them from the shores of Bad Vermilion river are mottled with lighter and darker greenish portions, but thin sections show comparatively little variation except in the amount of biotite or its decomposition product, chlorite. Examples of these rocks have been studied by Lawson[52] and by Winchel and Grant,[53] the latter writers paying special attention to the area with which the Wiegand-Ray gold veins are associated. In general the rock is very quartoze and a large quantity of plagioclase occurs with the orthoclase. The quartz has the usual granite appearance, and shows the effects of strain in undulatory extinction and broken crystals. The felspar is badly weathered in all the sections examined, so that one is sometimes in doubt whether orthoclase or plagioclase is present;

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[52] Geol. Sur. Can., p. 146F.

[53] Geol. and Nat. Hist. Sur. Minn., part III., 23rd An. Rep., p. 58.

but in many cases the latter seems to preponderate. The plagioclase is finely striated and sometimes displays a zonal structure and idiomorphic form. The darker mineral is generally biotite or its decomposition products, chlorite and epidote. In two sections (570 and 573) from Bad Vermilion river the biotite and chlorite make up more than a third of the rock; but in most others the green minerals are present in very much smaller proportions. The chlorite in 573 contains many rods and knee-shaped twins of rutile, rich brown yellow in color. One specimen from Bad Vermilion river (572) is made up chiefly of plagioclase, quartz and hornblende, the last mineral being in large amounts. It should perhaps be named quartz diorite, since no orthoclase can be recognized with certainty, though the plagioclase of this specimen is of the same type as that of the neighboring granites.

Other granite localities.

It is probable that careful search would reveal many other outcrops of granite in the Keewatin area. A medium-grained, greenish gray rock obtained on the west shore of Seine river a half mile below its mouth, proves, on examining a thin section (557) to be a granite rich in plagioclase and containing some chlorite, on the whole very like the Bad Vermilion granites, though the quartz is rather more crushed. Greenish gray granite has been obtained also on the Little Canada island, close to an auriferous quartz vein. A thin section (534) shows that it is made up of quartz, orthoclase, plagioclase, and a little chlorite associated with magnetite. It differs from the previous granites in habit, since the quartz and felspar, chiefly plagioclase, are generally intergrown, forming a rough pegmatitic structure, in which the plagioclase seems to have formed in a sense skeleton crystals, one or more individuals of quartz filling in the spaces. The country rock enclosing a large quartz vein, said to be auriferous, on the shore of Partridge lake, a long way east of the localities previously mentioned but apparently on the same band of Keewatin, resembles the rocks previously described, though it is darker green gray in color and even more weathered. In a thin section (531) one finds much quartz of the granite type, badly weathered felspar, some of which shows narrow twin striations, calcite and a considerable amount of chlorite and epidote, the last three minerals being associated and no doubt representing some basic silicate.

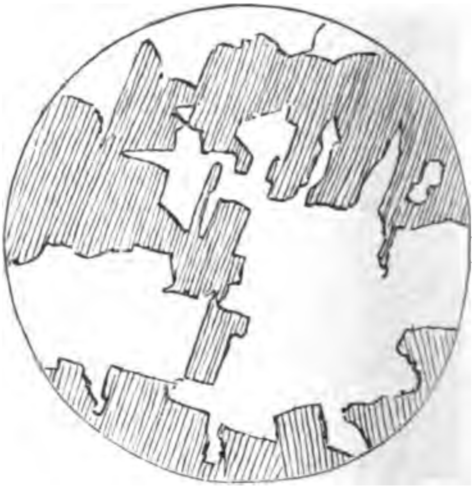

Fig. 15. Plagioclase, shaded in direction of striations, quartz white, lower part a single individual. Little Canada island.

GABBRO AND ANORTHOSITE.

Lawson includes certain gabbros with the diabases and other rocks of the lower Keewatin. It is however a little surprising to find these two rocks intermingled as if of the same age and formed under the same conditions. If it be true, as generally held, that diabase and other rocks having the ophitic structure have solidified under special conditions, including a comparative absence of pressure such as would be found at or near the surface of the earth, and that gabbro with other rocks of the granite type have solidified under quite different conditions, including an enormous pressure of overlying rock; one might infer that the two rocks could not have been formed at the same time in the same place. It is possible that the outcrops of gabbro in the Keewatin are always intrusive and of later age than the Keewatin diabases, but much detailed field work would be necessary to establish the fact. The mention by Lawson of rocks intermediate between the two, e. g. at Berry Island,[54] suggests that the whole series may be of approximately the same age and formed under the same conditions. Only two thin sections of gabbros, seemingly belonging to the Keewatin series, have been studied by the present writer; and since they present no points of special interest we may turn directly to the gabbros and related rocks that have undoubtedly pushed their way through the Keewatin as plutonic bosses. These have been studied specially in the Bad Vermilion and Seine river district, where they cover a considerable area in conjunction with three granite bosses, forming, according to Lawson, the eroded basis of a Keewatin volcano or group of volcanoes, from which part of the volcanic ashes and outflows of trap so characteristic of the Keewatin was derived.[55] The rocks of this area include some curious green and mottled porphyritic gabbros, or perhaps porphyrites, having a green ground mass crowded with well formed greenish or white plagioclase crystals; and also a large amount of anorthosite. The porphyritic rock occurs along the northwest shore of Bad Vermilion lake. Specimens obtained there contain felspars $\frac{1}{3}$ or $\frac{1}{2}$ inch long, sometimes tabular and rather thin, at other times stout and of a square shape. In some places however these felspar crystals so crowd one another as almost to exclude the green mineral forming the magma. Twin striations are readily seen on cleavage planes. Under the microscope (sections 514 and 515) one finds that weathering has progressed very far, the more basic mineral, no doubt some variety of augite, being completely changed to calcite and chlorite; while the felspars are sometimes reduced to aggregates of epidote and zoisite, and at others are filled with green chlorite, leaving only a rim and skeleton of unchanged plagioclase. These skeletons however sometimes have retained their freshness, so that twin striations are readily distinguishable. The extinction angles measured from the twin plane range from 9° to 14°, indicating a felspar more acid than labradorite; but only three measurements were made, and too much stress should not be laid on the result.

A question of their relative ages.

Intrusive gabbros and related rocks in the Keewatin,

in the Bad Vermilion and Seine river districts,

Lawson describes the rock on Bad Vermilion lake as "in many places, a fine white rock, resembling at first sight a coarsely crystalline marble. It is

and on Bad Vermilion lake.

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[54] Geol. Sur. Can. 1887, p. 65F.

[55] Ibid. p. 57F.

however much harder, and is for the most part mottled with the pyroxenic constituent. Under the microscope there is little to be noted, save that the anorthite is almost entirely changed to the aggregate of zoisite and albite, known as saussurite, and that the pyroxene is non-pleochroic and rhombic, though much decomposed, and difficult to determine accurately."[56] He names it a saussurite gabbro. Later he refers it, no doubt correctly, to the anorthosites of Dr. Adams, though he spells the name after the fashion of some American lithologists, anorthosyte.[57] Specimens of this rock collected at the upper end of Bad Vermilion river and on the shore of the lake near by answer to this description. The felspars here and farther north near the eastward bend of the lake are distinctly porphyritic, the outlines often corresponding to cross sections bounded by the prism and two sets of pinacoids. Some crystals are three inches in length and more than half that in breadth. The green constituent of the rock is reduced to a mimimum occupying the small spaces between. A microscopic examination shows an extreme degree of weathering in some instances, while in other portions the felspars still show twin striations. In the best section (513) the felspars are moderately fresh, so that the extinction angles can be measured without difficulty. The lowest readings are 15° and 18°, and the highest 35° and 37½°, the average of eight being a little over 23°, which indicates felspars running from labradorite to anorthite. The decomposition products observed are zoisite and a very little epidote and quartz. In all the thin sections examined the augitic constituent has completely disappeared, being replaced by very pale serpentine, calcite and epidote.

Anorthosites.

Outcrops of anorthosite occur at several points between the head of Seine bay and the mouth of Seine river. On a hill at the river's mouth a white rock occurs corresponding closely to that described. It is quite badly weathered and the angle of extinction could be determined in only three cases, which averaged 29°, the felspar approaching anorthite more closely than in the Bad Vermilion anorthosite. A comparison of these rocks with the typical anorthosites, so admirably described by Dr. Adams,[58] shows some unimportant differences, due perhaps to the advanced stage of weathering of the Bad Vermilion and Seine bay examples. The felspars do not show the violet color and the innumerable rod-like inclusions mentioned by him; and, so far as the writer has observed, have not the cataclastic structure so common in the anorthosites of eastern Quebec. The felspars appear also to have the porphyritic habit more frequently than in the east. The character of the felspar and its large amount as compared with the darker minerals are points of agreement.

Gabbro and granite.

A difference of opinion between Lawson and Winchell and Grant as to the relative age of these gabbros and the associated granites has already been referred to, Lawson placing the gabbro before the granite in age, and the other gentlemen after. The petrographic examination appears to favor the latter, for the granites have all the characters of rocks that have been subjected to strain and fracture, while the anorthosite, so far as the present writer has observed, presents no broken crystals nor undulatory extinction. The occurrence of fissure veins in the granite, as observed by myself and shown by Winchell and Grant, favors the same conclusion.

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[56] Geol. Sur. Can., p. 99F.

[57] Geol. Nat. Hist. Sur., Minn., Bulletin No. 8, 1893, second Part, p. 7.

[58] Ueber das Norian oder Ober-Laurentian von Canada, Stuttgart, 1893; and the Can. Record of Science, Vol. 6, No. 4.

Serpentines.

As an addendum to the gabbros, the serpentines may be mentioned. Specimens were obtained from Clearwater lake and from lake Despair. A thin section of the first shows only serpentine and magnetite; the latter, which Lawson visited but failed to get good specimens of because of a forest fire,[59] shows in one thin section (550) serpentine, magnetite, a pale mica with interleaved magnetite and remnants of other minerals, taken at first for augite. They have however the properties of tremolite, an angle of extinction running from 15° to 25°, and the hornblende cleavage. As they are dotted with magnetite, they themselves may be a secondary mineral after augite. Two or three remnants having a higher refraction and parallel extinction are no doubt olivine.

DYKE ROCKS.

Basic and acid groups of dyke rocks.

These, the latest rocks of the region, may be divided like the others into an acid group, including granite and pegmatite; and a basic group, including diabase and quartz diabase. Only one example of the acid group will be referred to, a fine grained, flesh colored, somewhat porphyritic granite occurring as a dyke in gray granite or granitoid gneiss at the north end of Sand Point island. Under the microscope it proves to contain quartz, orthoclase, microcline, a little almost invisibly striated plagioclase, probably anorthoclase, a little biotite and muscovite. The same individual of felspar sometimes shows very marked microcline structure at one point, and no trace of it in the rest of the crystal, an occurrence noticed now and then in granites from eastern Ontario. The structure is not sharply cut off, but fades out gently, and suggests a secondary origin, perhaps pressure.

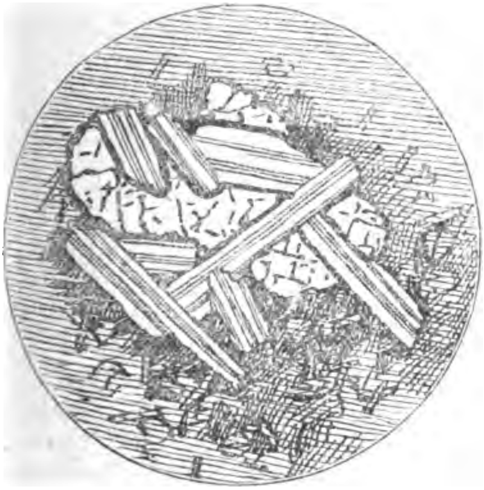

Fig. 16. Porphyritic Aggregate. Swell bay.

A basic specimen described.

Among the basic dyke rocks examined, a specimen from a dyke about a foot wide, running north and south through fine grained granite on location 166T, an island in Swell bay, is the most interesting. The rock is black, very fine grained, and contains small aggregations of pyrite. Under the microscope it proves to be a porphyritic diabase having an ophitic ground mass of plagioclase strips, chlorite, grains of brownish augite and magnetite. The augite is often idiomorphic and twinned, and seems to encroach on the felspar laths. In this magma are imbedded many elongated, idiomorphic felspars, colorless augites with idiomorphic or rounded forms, and more commonly still aggregations of these two minerals. The large augites often have a narrow margin of brownish, similarly oriented material, like the augite of the magma in appearance; and with polarized light they sometimes prove to be twins. In the aggregations we sometimes find a polysomatic mass of augite, but more generally a mixture of elongated plagioclase crystals and augite, the plagioclase having the more pronounced idiomorphism. Portions of the magma may be included in these masses, which are quite irregular in shape, and seldom contain magnetite, a mineral common in the ground mass. It is almost as though fragments of an older, less basic diabase were included in a dark colored later one; but the aggregates are so uniformly distributed and have so small a range as to dimensions as to make it more probable that they are really porphyritic.

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[59] Geol. Sur. Can. 1887, p. 98 F.

CONCLUSION.

The geologic sequence of events in the region explored.

In following the sequence of events in the geology of the region, we start with a widespread and voluminous deposit of very fine and uniform sands and clayey sands on a sea-bottom far enough from shore action to be free from pebbles, the Couchiching. The origin of the materials for these sediments and the character of the rocky bed on which they were deposited are points on which we have no very definite information, unless certain gneisses on Sand Island river, having alternate layers differing sharply in composition, be looked upon as remnants of an original Laurentian floor. After this time of quiet came an era of tremendous volcanic activity, ashes and scoria being rained down, partly perhaps on land, partly on the surface of the sea, to mingle with the beds of waterworn pebbles and boulders along the shore. From time to time there were lava flows, perhaps in widespread sheets like those of more recent geological times in the Western States. The basic lavas were followed by more acid ones, quartz porphyries and their tuffs, until thousands of feet of loose volcanic materials and lava sheets had buried the Couchiching sand beds and the uncovered or only partially covered rock floor to the north. The thickly blanketed underlying Laurentian rocks became hotter and hotter as ages went by, through the conduction of the earth's central heat outwards; until in spite of the tremendous pressure of overlying miles of strata, they reached a state of semifusion, were set in motion, perhaps by unequal loading; swelled into rounded summits, partially dissolving the overlying schists, floating off and bearing away great masses of them and nipping thick beds of them into sharp synclines in the intervening valleys. Slowly the molten mass cooled, hot water charged with silica and other substances in solution circulated in the innumerable fissures formed by previous convulsions and deposited the veins of quartz and other minerals. Meantime the shattered higher portions of the Huronian rocks, forming the summits of hills or mountains, were eaten away and removed by the action of water, and the surface was at length worn down to a plain; leaving meshes of pinched-in Couchiching and Keewatin rocks surrounding bare areas of gneiss, and here and there disclosing the bosses of granite or anor-

An era of volcanic activity

and rock disturbance.

Origin of fissure veins.

thosite representing the bases of vanished volcanoes. There is no evidence that any rocks later than the Huronian were ever deposited in the region, which has possibly been dry land since that far off time. Certainly if any fossiliferous strata once rested upon the Archaean, erosive forces have completely removed them. The only further point to be noticed is the work of glacial times, when the surface was scoured and furrowed and deposits of loose materials laid down toward the southwestern end of the region.

FLORA OF THE RAINY LAKE REGION.

While our summer's work was specially devoted to studying the gold deposits on the shores of Rainy lake and its tributaries, the plants and animals of the region and its sparse human inhabitants could not fail to attract our attention, and it is proposed to give here a brief sketch of them. Practically the whole of the dry land of the region, where not simply bare rock, either is or was formerly forest covered; and the forests before the action of fire were mainly of coniferous trees, pines and spruces. Three kinds of pine occur in large quantities, the ordinary white pine (*Pinus strobus*), the Norway or red pine (*Pinus resinosa*), and the Banksian or jack pine (*Pinus Banksiana*). The two former trees give the main value to the timber limits of the region, and in voyaging by canoe through the more remote watercourses one still sees here and there fine groves and bunches of these valuable timber trees. As a rule however they are decidedly smaller than the pines once so common in eastern Ontario. The white pine is habitually mixed with other trees, and on this account is more readily injured by fires, which rapidly spread by reason of the dead leaves and underbrush at dry seasons of the year. The somewhat less valuable red or Norway pine occurs in much larger quantities than the stately white pine, and commonly forms groves which more or less completely exclude other trees. These groves of tall red trunks with their crown of dark green showing distinctly along the hills, with little or no underbrush, are very impressive to look upon. The red pine, partly no doubt from the absence of undergrowth, withstands fire better than any other tree in the region. There is little material at the base in which the fire can run, and the thick, non-conducting bark of the trunks prevents fatal injury if the fire sweeping through is not too fierce. In woods of mixed timber it is a surprise to see splendid red pines left apparently uninjured after the surrounding trees have been burnt to a crisp and ruined. The red pine seems to grow to fair dimensions on a minimum of soil, often apparently rooting itself in the fissures of the bare rock. The jack pine never reaches the size of the other two species of the genus, and is usually too scrubby for use, though many trees would furnish railway ties if they were in demand for this purpose. As long however as better timber is available it seems as if this tree would remain untouched. It is no doubt the most generally diffused pine of the region.

Coniferous trees.

White,

red and

Banksian pines.

Of other coniferous trees, the deciduous tamarack *(Larix Americana)* occurs sometimes in swampy tracts, but the spruces are very much more common, forming monotonous woods often of uselessly small trees along many miles of the muskeg borders of the sluggish streams. Cedar is seen comparatively rarely, and not often of such dimensions as to be of value.

Tamarack and spruce.

Deciduous trees: poplar, birch, elm, oak, maple and ash.

Deciduous trees of little value, chiefly poplar and birch, are very widespread, especially where fires have run; these trees commonly forming the second growth, their seeds having more efficient means of dispersion than the rather heavy and only slightly winged seeds of the conifers. Along some of the rivers, elms give a pleasant variety, and oaks, maples and ashes are also found, though more rarely.

Shrubs and flowers.

There are of course many woody plants of lower growth, giving a dense underbush in many places, and including berry-bearing shrubs, such as the blueberry and cranberry. The minor flowering plants it would be unwise to attempt to enumerate. The traveller by canoe cannot fail to be attracted by the magnificent white water lilies along the more sluggish streams, where the moose has not worked destruction by tearing up their roots from the mud to feed upon them. Yellow water lilies are numerous of course, and there are dwarf species of both colors with tiny flowers a half inch in diameter in some parts of the watercourses.

Rice.

In the wide swamps along the shores of muddy lakes and rivers the wild rice thrives on the muddy bottom, though it is much more abundant to the north near lake Wabigoon than in the neighborhood of Rainy lake.

Cactus.

A most interesting find was a tiny patch of cactus on Red Pine island, in Rainy lake. The plants are small and very prickly, and appear to grow only in a spot of lichen-covered rock a rod square on the island mentioned, since our halfbreeds, who knew of its presence there, had no knowledge of its being found elsewhere. Dr. Macoun has determined a specimen to be Opuntia fragilis, and states that a few specimens of the same species were found by Dr. Lawson ten years before on an island in the Lake of the Woods.[60] These are the only known localities where the cactus grows wild in Ontario.

Forest fires, and their terrible ravages.

The flora of the region includes beside the two timber producing pines comparatively few plants of much economic value, though the berries and the wild rice afford a harvest of some importance to the Indians. But little pine has been cut during the last two or three years, on account of the depression in the building trade; but probably a considerable amount has been cut during the past winter, for the sad reason that the trees have been killed by fire and if not put into the water within a year or two will be rendered worthless by the borers. If the spread of forest fires is not prevented the time is not far distant when the pine of the Rainy Lake region will be at an end. The fury of these fires is not conceived by the dweller in the cleared and settled east. The present writer found himself last August in the range of a terrible fire which swept over hundreds of square miles of territory in the neighborhood of the Atik-okan river and the chain of lakes between it and and Lac des Milles Lacs. So dense was the smoke that on even narrow lakes the canoe had to be steered by compass, unless one were content to coast slowly along the shore. On Baril lake, August 29th, the air was so thick with smoke and falling ashes and cinders that it became dark at noon day, and we simply had to land and wait on the blackened, fire-ravaged shore till the worst of the gloom had been washed out of the air by a shower. The flare of blazing trees at night in the half choking atmosphere made one very careful to camp where the fire had already passed, leaving nothing more to burn. So furious was the conflagration that birds were killed in the air, and in the case of one small lake all the fish perished, and floated dead on the surface when we passed a day or two later. Large trees are not burned completely by these fires, as a rule, but are generally killed, and in a very short time the blackened trunks are invaded by the larvæ of *Monohammus confusor* or *M. Sentellatus*, which tunnel into the wood and destroy it. The ceaseless sound of their rasping horny jaws can be heard at times for a quarter of a mile away from these shadeless, funereal forests, and little heaps of sawdust soon accumulate at the foot of each tree.

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[60] See Canadian Record of Science, vol. vi, No. 4, 1895, p. 201.

THE FAUNA.

Moose, caribou and red deer.

The Rainy Lake region seems one of the favorite haunts of the moose, the largest of American mammals since the practical extinction of the buffalo, and many of them are killed for food every year, the flesh of one in good condition being unsurpassed. If the Indians are to be trusted, they are increasing in numbers. The caribou too is common in some parts, but the red deer is very rare; in fact our halfbreeds informed us that the red deer were unknown until five years ago, but that now they are gradually coming into the country. With the red deer doubtless will come their inveterate enemies, the wolves, so rare at present that we neither saw nor heard one during the summer. Black bears are not infrequent, and the smaller fur-bearing animals provide a large part of of the Indian's income. All the ordinary wild fowl of Canada are numerous, and no more delicious ducks can be found than those that have fattened on the wild rice of the Wabigoon. Gulls frequent the larger lakes, and loons rouse the echoes on the smaller ones with their mournful cry. Fish are abundant, though not always of the best. Whitefish are caught in the larger lakes, trout in the clearer ones, and black bass in only one lake out of the thousands. Tormenting insects are numerous and venomous in their season, almost the worst being the dogfly, an innocent looking insect like a housefly, but smaller, which reduces the ears of the Indian dogs to a mass of raw flesh. The dragonfly here as elsewhere cruises in the dusk for its favorite food, the mosquito.

Bear and wild fowl.

Fish.

Insects.

THE INDIANS.

Indians of the Rainy Lake reserves,

The Indians of Rainy lake speak the Ojibeway language, and are scattered as small bands on reservations here and there through the region. They are reputed to be pagans as a rule, though the Church of England and the Roman Catholic Church have each a few adherents among them. Although provided with reservations on which a certain amount of land has been cleared and small log houses built, they appear to do very little in the way of farming, and depend for a livelihood mainly on fishing, trapping and hunting, the proceeds being eked out by the sale of blueberries, which they ship to Rat Portage; and by gathering a few bushels of rice, of whose long black grains they are very fond. On each reserve they have a small herd of cattle. Their most important manufacture is the bark canoe, for which they find a ready sale at present to explorers. The Rainy lake canoes are only moderately good, since the birch bark to be found in the region is from comparatively small trees. That they have some artistic taste is shown in their stone pipes, which are sometimes elaborately and prettily carved.

and their characteristics.

As canoemen and pioneers many of the halfbreeds from the settlement near Fort Frances are very efficient, and a few of them, who have had training under Hudson Bay officials, are good camp cooks. Both halfbreeds and Indians are keen observers, and several gold locations have been taken up on information given by them. They are beginning now to know the value of gold and to join prospecting parties, but their greatest drawback is their want of knowledge of English, which however they will doubtless pick up with many less desirable accomplishments as white men pour into the country. Many of them have a dangerous craving for liquor, which they can now satisfy by crossing the line to Rainy Lake City or Koochiching; but away from such temptation they seem to be harmless and peaceable. What effect the sudden influx of hundreds or thousands of adventurous white men will have upon these isolated and ignorant communities of half civilized Indians remains to be seen; but it is to be feared that their morals at least will hardly be changed for the better. It is doubtful if the policy of placing them on small scattered reservations with only a few scores of inhabitants in each is a wise one under present circumstances. On a single large reserve they could have much more efficient oversight and protection from the sale of liquor; and the children, who are now only nominally educated, and in many cases not at all, could be gathered into good schools.

Gold discoveries on the reservations.

If discoveries of gold are made on these reservations, and there is every probability that this will occur, there will be a demand for some re-arrangement of present conditions by which these lands, now locked up from the enterprise of white men, may be developed as their resources demand. The chief of one of the reservations, having found what he believed to be a gold bearing vein on his land, enquired of the writer how he could dispose of it, since he and his tribe wanted the money it would bring. At present of course these wards of the Crown can transact no such business except through the somewhat slowly revolving machinery of the Indian Department; and he was informed that nothing could be done except through the agent in charge of the Rainy Lake reservations.

THE McGOWN MINE IN FOLEY.

Location of the property.

Early in October a visit was made to a new and very interesting gold deposit, the property of Thomas McGown and Sons, Parry Sound. The deposit is situated just north of the Parry Sound-Rosseau colonization road, two or three miles east of the former town. The gold occurs in a bedded vein, or rather a series of parallel veins and stringers, having a width of about 3 feet and extending about 100 feet, so far as exposed by stripping. Beyond these limits it has not been traced with certainty. The vein has a strike of 70° west, parallel to the enclosing rocks, and dips 40° to 50° to the south. The gold occurs as small nuggets and scales in vitreous quartz associated with copper sulphides, chalcocite or copper glance, bornite or peacock ore, a little copper pyrites, and their decomposition products, oxides of iron and malachite. The chalcocite and bornite are mixed, and sometimes form quite large lumps. The gold may be found in the quartz, in the sulphides, and between the two.

Occurrence of the gold.

An assay of the bornite gave $4 per ton of gold. No iron pyrites was observed. It is probable that on sinking on this vein the sulphides will change to copper pyrites.

The vein rock

As vein rock there is, besides quartz and portions of intermixed wall rock, a curious brownish, fine grained material consisting of quartz, confusedly disposed muscovite, and brown and red garnet, the latter often enclosing patches of green epidote, no doubt a decomposition mineral. There is also a little titanite of almost the same color as the garnet.

and the country rock.

The country rock in which the vein occurs consists of a speckled gray, slightly schistose rock resembling diorite, or diorite schist. On examining thin sections one finds that part of it at least is a gabbro of somewhat unusual habit, made up of about equal amounts of plagioclase, augite and hornblende, with biotite, apatite and sulphides as accessories. The plagioclase has not the ophitic shape, is in general clear and unweathered, but has its twin planes bent. The twinning is after the two usual laws, having angles of extinction corresponding generally to labradorite, though angles as low as 10° were observed. At the edges of some felspars an appearance very like micropegmatite is sometimes seen, but no quartz beside this is to be found. Part of the augite is green, not pleochroic, has a high angle of extinction, and sometimes contains parallel platelike inclusions, but beyond this has not the look of diallage. Another part of the augite, probably hypersthene, is quite strongly dichroic (pale red and green), contains no inclusions, and in some cases has parallel extinction; but in others must be rotated about 5° from the predominant cleavage before extinction takes place. The two minerals are much alike in cleavage and general appearance, and often have a thin margin of green hornblende. The hornblende, which is compact, green and strongly pleochroic, is probably of secondary origin; and the same is true of the brown biotite. The apatite forms thick prisms.

Minerals of the neighborhood,

In the neighborhood we find thick dykes of pegmatite intersecting the gray schistose rocks; and a mile or two to the west, within the limits of the town, greatly contorted gray schists and gneisses of totally different appearance are found, having the *augen* structure very strongly marked. The augen, which are sometimes two or three inches in longest diameter, are almost pure white, and generally show an oval individual of striated felspar, surrounded by a granular layer, no doubt of the same mineral crushed. Occasionally a large crystal of black hornblende occupies a similar position. A thin section of the gray rock proves to contain quartz, othoclase, perfectly clear and white, but with cleavages distinguishing it from the quartz, a little plagioclase, with very low angles of extinction, and hornblende. A little biotite, a number of pale garnets and a very few zircons complete the list.

Near the harbor exceedingly coarse grained pegmatite veins cut through the schistose rocks, their felspars sometimes showing cleavage planes two feet in length. The "graphic" arrangement of quartz and orthoclase is not uncommon in these dykes.

and at Parry Sound.

Just at the limit of the corporation a bed of coarsely crystalline, flesh colored limestone is exposed near the roadside. It contains a good deal of biotite in bands, and also many contorted and broken fragments of gneiss, as though it was an eruptive rock. No doubt during the folding of the tougher schists the limestone has been squeezed, as the more yielding material, into openings, probably at synclines and anticlines, and has swept with it some fragments of gneiss. The general character of the rocks in the neighborhood of Parry Sound, so far as observed during two stormy days of October, suggests the Grenville series, or Upper Laurentian; but the region would repay a careful study in detail.

rious cop-
r ore.

Up to the present the McGown gold deposit, with its interesting and unusual association of minerals, stands alone, since gold has not been found elsewhere in the district. A curious copper ore has been obtained however some miles south of Parry Sound; a mixture of copper pyrites, iron pyrites, zincblende and garnet; but this has not proved to be auriferous.

SECTION III.

THE HINTERLAND OF ONTARIO.

Geographical position of the province.

The province of Ontario occupies a unique geographical position, a position which confers upon her singular advantages for purposes of trade and commerce. To the south of her lies the magnificent chain of lakes which contains about one-half the fresh water on the globe, and the remarkable fact is that the entire northern coast-line of these inland seas—lake Michigan, which is wholly within the United States, excepted—is formed by Ontario territory. Even beyond the vast basin of lake Superior her southern limit extends until it strikes the province of Manitoba at a point midway between the Pacific and the Atlantic oceans. The international line dividing Canada from the United States runs through the middle of the lakes, and faces the northern boundary of New York, a small part of Pennsylvania, two-thirds of Ohio, the whole of Michigan and Wisconsin and nearly the whole of Minnesota, and yet confronts the territory of Ontario all the way. Her southwestern peninsula, surrounded almost on all sides by the commerce-inviting waters of these lakes, cleaves the very heart of the great republic, and brings her people and her products into touch with the largest cities, the richest areas and one-half the population of the United States. Her eastern corner is but a few miles above ocean communication at Montreal. Her rivers run east into the St. Lawrence, south into the great lakes, west into lake Winnipeg and north into Hudson bay. No immense mountain ranges divide one portion of the province from another, or render railway building in any direction an impossible or difficult task, or make her streams and rivers subject to the dangers of overflowing at flood time. Her climate varies from the warmth and geniality of the lake Erie counties and the Niagara peninsula to the sub-arctic rigor of the country inland from lake Superior; while the fertility of her soil, the wealth of her natural resources and the extent of her territory are such as to give her a commanding place not only among the provinces of the Dominion, but also among the commonwealths of the continent.

THE HINTERLAND TERRITORY.

Extent of the province,

The area of Ontario is estimated to be 126,000,000 acres, or approximately 200,000 square miles. About 60,000 square miles of this lie south of the French river, lake Nipissing and the river Mattawa, and until a very recent date comprised all that was thought of as forming Ontario or Upper Canada, as it used to be called, and a very large extent of country besides. South of this line are situated the bulk of the population, the cities and towns, a large proportion of the arable lands, the manufacturing industries, the schools and colleges; in a word the greater part of the civilization of the province. North of it, at the back of the cultivated and settled districts, stretches the and of the Hinterland.

Hinterland of Ontario, a vast region reaching from lakes Huron and Superior on the south to the Albany river and James bay on the north, which has for its eastern limit the boundary line between Quebec and Ontario, and for its western limit Rainy river and Lake of the Woods. This whole territory contains an area of about 140,000 square miles, of which perhaps 80,000 square miles lie on the Hudson Bay slope north of the height of land. This height of land is the watershed which divides the streams flowing into the Atlantic ocean through the St. Lawrence from those emptying into Hudson bay. Its course is extremely irregular, but may be described as follows: Beginning at a point on the eastern boundary of the province near Labyrinth lake, which lies between lakes Temiscaming and Abittibi, in latitude 48° 15′ north, it follows a southwesterly direction past the great bend of the Montreal river until within 50 or 60 miles of the north shore of Georgian bay, whence and approximately at this distance it continues parallel to the coast and the east and north shores of lake Superior, until north of Michipicoten island it makes a great deflection to the southwest. Passing round the southern end of Long lake it approaches within 20 miles of lake Superior at a point north of the Slate islands; thence turning to the north and west it makes a bold curve around the head of lake Nepigon at a distance of 20 miles; and passing 50 miles west of that lake and lake Superior in a southwesterly direction it crosses the international boundary between the province of Ontario and the state of Minnesota at the source of the Pigeon river. The height of land is not a range of mountains, nor even a ridge of hills. It is rather an upland or plateau of varying width, but of remarkably uniform height, varying from 1,200 to 1,500 feet above the level of the sea. The whole region under consideration indeed, viewed on the large scale is extremely level, and the scenery though diversified by hundreds of rivers and streams, thousands of lakes and innumerable crags and hills of rock, is certainly lacking in that nobility and largeness of view which only the presence of lofty mountains can bestow.

Position of the height of land,

and its effects on the topography of the country.

A glance at the map will show that the position of the dividing ridge is attended with important consequences to the topography of the country. The rivers which flow southward into the great lakes are much shorter and of smaller volume than those which run northward into Hudson bay. The Kaministiquia, the Nepigon and the Michipicoten are the only important streams falling into lake Superior on its northern side. The Mississaga, the Spanish, the Wahnapitae and the French (which forms the outlet of lake Nipissing) are the largest tributaries of lake Huron, whose feeders are on a grander scale than those of lake Superior.

One may notice in passing the smallness of the drainage areas of lakes Superior and Huron as compared with the immense size of these bodies of water. This peculiarity, it seems probable, may have some influence in causing the fluctuations noted in the level of these lakes. Coupled with the rocky, unretentive character of the soil, which provides a minimum of capacity for absorbing moisture, and the scarcity of important lakes to act as feeders, the smallness of the basin renders it likely that the successive falls of rain and snow are carried away during the season in which they are precipitated. In this way an unusually dry or wet year would take immediate effect upon the level of the lakes, there being but little ground for the water to traverse and very few great settling basins in the shape of large lakes to retard and equalize its flow.

The north bound streams on the other hand, though less known to fame, much surpass in size those flowing south. The principal of these are the Albany, which has a length of about 475 miles, its branches the Ogoké and Kenogami, the Missinaibi or North Moose, the Mattagami or South Moose, 270 miles long, and the Abittibi, 216 miles. All these are large rivers with numerous tributaries. During the season of high water shallow draft steamers might ascend the Moose and two of its branches for upwards of 100 miles and the Albany for 250 miles, or as far as Martin's Falls. The Rainy river, which rises not far from the western shore of lake Superior and empties into Lake of the Woods, and so finally into Hudson bay, is navigable from Lake of the Woods to Fort Frances, near Rainy lake, and is really a part of the northern water system; while the Montreal and Blanche, which run southeasterly into lake Temiscaming, belong to the southern system.

THE SOUTHERN SLOPE.

Opened up by the Canadian Pacific Railway.

The country south of the height of land, though by no means well known, is yet more familiar to the people of older Ontario than the Hudson bay slope. The building of the Canadian Pacific Railway, whatever else it may have done or entailed, has certainly been of great benefit to this province in affording means of access to a large portion of the public domain which would otherwise be still as inaccessible as the district north of the height of land. The general impression is that this whole tract of land lying north of lakes Huron and Superior traversed by the railway is a barren and inhospitable wilderness. Minerals have been discovered at certain points and the lumber industry certainly thrives, but as for ever supporting an agricultural population on these ridges of granite, the idea is preposterous. And yet preposterous as it is, the thing is being done. It is being found out that the country is more forbidding in appearance than in reality. The rocky bluffs in many places hem in fertile flats, and in the valleys of the numerous streams and rivers there are many tracts of first-rate land of considerable extent. The railway gives easy access, and the lumbering industry affords a steady market for all agricultural products. On lake Temiscaming, round Mattawa, North Bay, Sturgeon Falls, Sudbury, Chelmsford, Webbwood, Massey Station, Thessalon, Bruce Mines, Sault Ste. Marie and Goulais bay, as well as on Manitoulin and St. Joseph islands, there are thriving settlements, and in some places farms which would not disgrace the older parts of the province. The north shore of lake Superior is not as yet much affected by settlers, and probably contains but little good land. But in the townships around Port Arthur there is a considerable farming population; while in the fertile, well-timbered valley of the Rainy river there is room for thousands.

The lumbering industry.

The chief industry of the district is lumbering, which is carried on with greater or less activity, according to the state of trade, on almost all of the rivers running into lake Huron and the Ottawa. The only timber that is cut for purposes of lumber is the pine, but of late years a growing business has been done in timber suitable for the manufacture of paper, or as it is called, pulpwood. The tree that is most in demand for this purpose is the spruce, which is cut into four-foot lengths and floated down stream to be loaded into barges and taken to the United States, where the work of manufacture is carried on. There are no paper mills on the Ontario side, though one would imagine the nearness to the source of supply would be a great advantage. It is understood that this want may in part be soon supplied. Great rafts of saw logs are every year towed across Georgian bay and lake Huron to be manufactured into lumber by American mills. The recent change in the United States tariff by which lumber is admitted free is however having the effect of transferring a considerable proportion of this industry to the Ontario side.

Farm products.

The principal farm products in all the region south of the height of land are hay, oats and potatoes, for the growing of which the land is well adapted, and which all find a ready market in the lumbering camps at higher prices than can be had in the older parts of the province. Indeed there is not enough hay and oats raised in the district to supply the local demand, and quantities are regularly brought in every year to make good the deficiency. Peas are largely grown, and are found to be free from the bug which infests the crop in other parts of the province. Little or no wheat is sown, as the district is almost universally supplied with Manitoba flour.

THE NORTHERN SLOPE.

Backbone of the continent.

Ontario, south of James bay, is interesting from a geological point of view, as most of it lies within that great Archæan area which was the first part of North America to rise above the waters of the primordial seas. This nucleus or backbone upon which the remainder of the continent has been built up has been described as extending from the region of the great lakes in the form of two arms, one stretching eastward to the Atlantic coast and the other northwestward to the Arctic sea east of the mouth of the Mackenzie river. Its full outline is probably in the shape of an ellipse, including on the east Baffinland, Greenland and many of the islands of the frozen sea, and on the west stretching from lake Winnipeg to Coronation gulf, with a spur towards the mouth of the Mackenzie river. The palæozoic rocks of Hudson bay form a sort of broken fringe around that inland sea, and a belt of them extends thence northward across some of the islands to the Arctic ocean. The geographical depression of Hudson bay, to which the rivers flow from all sides, forms the central drainage basin of the azoic area of North America, and its origin is of very ancient geological date. Taken as a whole, northern Ontario is probably largely Laurentian in geological character, though extensive areas of Huronian strata also occur. The great Huronian belt lying to the north and northeast of lake Huron and reaching from the east end of lake Superior to the line between Ontario and Quebec (where it is 100 miles wide) and far into the latter province, is perhaps the largest of these areas.

Laurentian and Huronian areas.

Palæozoic rocks of the north.

The palæozoic and tertiary basin of James bay is quite distinct in its general features from the Laurentian and Huronian plateau to the south. The latter is elevated, undulating, and dotted with hundreds of thousands of lakes, containing in the aggregate an enormous quantity of fresh water, while the former is low, level and swampy, and as far as known generally free from lakes. The southern edge or rim of this basin is formed by the hard, ancient rocks composing the base of the height of land. Owing to the unyielding nature of these rocks, all the rivers running into James bay meet with a great and very rapid descent on reaching the edge of this basin. As a consequence the long portages on the Abittibi, the Mattagami, the Missinaibi and the Albany are all to be found where they pour their waters down this slope a short distance southward of the margin of the palæozoic rocks. In ten miles the Missinaibi falls nearly three hundred feet, and the Mattagami not less than four hundred and twenty-five feet in a like distance.

AN UNEXPLORED REGION.

The unknown interior.

As has been already said, the region north of the height of land, and to a considerable extent south of it, has been very partially explored. Some portions of it have never yet been trodden by the foot of the white adventurer. There are rivers many miles in length, whose existence is known, but whose courses remain only as dotted lines on the map. The sole means of travelling is the canoe, and hence only the country in the immediate vicinity of the rivers has yet been described from ocular observation; for a journey from the great lakes to James bay is both difficult and uncertain, and little or no attempt has been made to penetrate far into the interior away from the water highways. Dr. Robert Bell of the Dominion Geological Survey and Mr. E. B. Borron, stipendiary magistrate for the district of Nipissing, are perhaps the only two scientific observers who have made systematic examination of the region on an extended scale, and it is to these two intrepid explorers that we owe a very large part of the information we possess concerning it. Dr. Bell has conducted a number of expeditions to Hudson and James bays by various routes, and has made a study of the geology and resources of the district. Mr. Borron, as an officer of the Government of the province and an old miner, has contributed a good deal to our scanty stock of knowledge concerning its minerals. The engineers of the Canadian Pacific Railway in the early days of that undertaking, explored a considerable tract of the country from east to west across the several branches of the Moose river, and their reports are valuable as constituting the chief source of information respecting the character of a considerable part of the region inland from the waterways both north and south of the height of land. A short description of the district between North Bay and lake Temiscaming is given in the report of the Commission on the Mineral Resources of Ontario by Mr. J. C. Bailey, who explored it in 1889 in the interest of the Nipissing and James Bay Railway, of which he was engineer. This section is, however, comparatively well known, a colonization road 83 miles long having been built by the Department of Crown Lands between these points and finished in 1888 at a total cost of $13,800.

Sources of information respecting it.

CLIMATE OF THE HINTERLAND.

Comparative latitudes.

The territory under treatment extends from latitude 46° 30′ to 52° north, a distance of about 400 miles. What is its climate? The whole of Ireland and Scotland, and nearly the whole of England lie farther north than the most northerly point of this territory; so do Denmark, Norway and Sweden, large portions of Germany and the Russian possessions in both Europe and Asia. Part of this great lone land extends a considerable distance south of the latitude of the international boundary between Canada and the United States, and is in the same zone as France, Switzerland and Austria; the central portions are in the same latitude as Manitoba and the settled part of British Columbia; while the whole of it is south not only of the ranches of the Peace river, but also of the wheat-growing lands of the Saskatchewan. A large portion of the territory lies farther south than the gulf of St. Lawrence, and a considerable part in the latitude of New Brunswick and the state of Maine. But mere latitude does not make a climate, and it is evident that the tempering influence which the gulf stream exercises on the British isles, for instance, is wanting here. Instead we have the vast expanse of Hudson bay, opening on the north into the Arctic ocean and exposed to the influence of the icy currents which flow southward from the frozen regions of the pole. The lowering effect of Hudson bay on the climate of the territory to the west and south must be considerable, but it is doubtful whether on the whole it is not largely counteracted so far as those parts of Ontario contiguous to James bay are concerned by various circumstances of an ameliorating kind. The question of altitude has quite as great a bearing on climate as that of latitude, and in this respect northern Ontario possesses a decided advantage, for, as has been said, no part of it rises more than 1,200 or 1,500 feet above sea level.

Causes which influence the climate.

Ocean currents.

"The climate," says Dr. Bell, "in going northward from the height of land towards James bay does not appear to get worse, but rather better. This may be due to the constant diminution of the elevation more than counterbalancing for the increasing latitude, since in these northern regions a change in altitude affects the climate much more than the same amount of change would affect it in places further south. The water of James bay may also exert a favorable influence, the bulk of it being made up, in the summer time of warm river water which accumulates in the head of the bay and pushes the cold sea water farther north. The greater proportion of day to night during the summer months may be another cause of the comparative warmth of this region."[1]

Altitude.

Length of day in summer.

Mr. Borron states that "the climate of this territory in respect of temperature is one of extremes. The winters are cold—the temperature falling sometimes as low as 40° below zero of Fahrenheit's thermometer, and occasionally rising to 90° in the summer even down on the coast. Last year (1881) it was on one occasion 94° in the shade at Albany Factory and 92° at Moose Factory. The mean temperature at Moose Factory of the summer is about 60°."[2]

A temperature of extremes.

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[1] Geological Survey Report, 1875-76, p. 341.

[2] Report on Basin of Moose River and Adjacent Country, 1890, p. 24.

In 1880 the mean average temperature at Moose Factory was: May 40°, June 55°, July 59°, August 55°, September 52°, October 38°. In his exploration of the east coast of Hudson bay in 1877 Dr. Bell says he took the temperature of the sea upwards of 20 times during July, August and September, and found it to average 53° Fahr. The average of the water in five of the rivers was 61°. In the same year the doctor states that at Moose Factory in the end of September he found there had been no frost all summer, and the most tender plants such as melons and cucumbers, beans, balsams, tobacco, the castor oil bean, etc., growing in the open air, were still quite green and flourishing. The summer of 1877 was however, Mr. Borron remarks, probably a finer one than usual. The rain fall at Moose Factory in 1878 was 26.86 inches.

Records of temperature by Dr. Bell.

The Hudson's Bay Company's officials raise potatoes and other vegetables in abundance at Moose Factory, as well as barley, which ripens, though not every year, and upwards of eighty head of cattle are kept there, besides horses, sheep and pigs. At the mouth of the Albany, about 100 miles north from Moose Factory, the soil and climate are not much different, and the marshes on the coast furnish abundant food for cattle. Potatoes yield bountifully in almost every part of the territory where they have been tried. The Colorado potato bugs had not reached Moose Factory at last accounts, but were numerous at Lake Temiscaming, and had got as far north as the height of land. Barley, oats and wheat are also grown with greater or less success at various H. B. posts, and all the ordinary garden vegetables are cultivated without difficulty.

Farm products at H. B. Co.'s posts.

In the less remote districts the climate is well known. It cannot be denied that the winter is severe and long, measured by the standard of Toronto. But wherever settlement has taken place there is found to be ample time in the spring, summer and autumn months for the growth and ripening of crops, and no complaint is made that farming operations are materially retarded by climatic conditions. This applies to the settlements on the Rainy river and along the main line of the Canadian Pacific Railway, as well as to those north of lake Huron and at lake Temiscaming. Mr. C. C. Farr, a long resident at the latter place, says that while it would be misleading to say there are no summer frosts in that district, yet anything that can be grown in a temperate climate can be grown there, and in his list of vegetables, cereals and fruits he enumerates such tender plants as beans, melons, tomatoes, cucumbers and tobacco. Seeding time, he says, commences about the first week in May, haying about the 14th of July, and harvest the 15th of August. The fall is open, and the large lake seldom frozen before the second week in December. From these facts it is evident that the climate of the Hinterland is far from being a hyperborean, or even a frigid one. It is the climate of older Ontario, somewhat intensified in winter.

Climate of the less remote districts favorable for farm crops.

LAND AVAILABLE FOR AGRICULTURE.

Dr. Bell's testimony.

The proportion of land available for agricultural purposes is difficult to estimate. Dr. Bell says: "Loose materials of some kind actually cover the greater proportion of the area, and in a very considerable percentage of it the soil is more or less suited to agriculture. In a general way there is perhaps a greater proportion of good soil in the plateau region northward than southward of the height of land."[3] Again the same gentleman remarks: "The country immediately surrounding Hudson bay cannot be said to be an agricultural region, but to the southward of James bay, the southern prolongation of Hudson bay and to the southwestward, there is a long tract of land which sooner or later will be, I believe, of value for agricultural purposes. It extends for a distance of nearly 200 miles in a southerly and southwesterly direction The immediate shore of James bay, towards the south end, and the country for some distance back, is covered with sphagnum moss, but this does not exist far inland. The greatest extent is between the lower parts of the Albany and Moose rivers, but beyond that there is a level tract of excellent land, well wooded, and southward and southwestward of that again the country rises pretty rapidly for a short distance and we come upon a plateau which extends inland for another 100 miles, and over the greater part of that the land is excellent as far as I could judge. I have surveyed all the principal rivers and lakes and canoe routes of that country, and made excursions inland to see the rocks and the soil, and it would be what we should consider in western Canada good land."[4]

THE C.P.R. EASTERN OR WOODLAND DISTRICT.

It will be remembered that the Canadian Pacific Railway as at first projected took a much more northerly route from Mattawa to Winnipeg than that which was actually adopted. This portion of the line constituted the Eastern or Woodland division of Sandford Fleming and the early engineers, and as the region which it traversed was then even less known than it is now, it was deemed expedient to put a number of surveying parties in the field to examine the country and lay down the most practicable route for the railway which the admission of British Columbia into Confederation made it necessary to construct. This exploratory survey began in June, 1871, and the work undertaken, covering as it did an extent of about one thousand miles through a trackless wilderness, far from supplies and means of communication, was one of unusual difficulty. The reports of the various parties made from time to time as they succeeded in accomplishing the task set before them contain a good deal of valuable information. The prime object was, of course, to find a suitable railway line, but the character of the country, its suitability for agriculture, and its resources of timber and minerals were hardly less important, as indicating the sources from which the future railway would derive business and revenue. A map of part of the Dominion of Canada issued by the Department of Crown Lands in 1877 shows the Canadian Pacific line as

Evidence of the C. P. R. exploratory survey.

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[3] Report of the Geological Survey of Canada, 1875-76, pp. 339, 340.

[4] Evidence before Immigration and Colonization Committee, House of Commons, 1883, Dom. Sess. Papers, 1883, Appendix No. 6, p. 52.

then located to run from Mattawa up the Ottawa river to the junction of the Montreal river with lake Temiscaming, thence up the valley of the Montreal to the great bend of that river, thence crossing the various branches of the Moose to the southern end of lake Kabinakagami. From this point two alternative routes are shown, one running north of lake Nepigon, the other tending towards lake Superior and south of lake Nepigon, but both converging after leaving the latter body of water, passing south of Lac Seul (Lonely lake) and north of Lake of the Woods, and uniting at a point on the Winnipeg river some distance east of Winnipeg, or, as it was then called, Fort Garry. In describing the country through which this trial line was run Mr Fleming says:

Sandford Fleming's description.

"Compared with the country on the Pacific coast no part of this region can be considered mountainous. Along the shores of lakes Superior and Huron a considerable extent of rough and broken elevated ground is found, but the maximum elevation attained in the highest portion of this woodland region will not exceed 2,000 feet above sea level. The band of rocky hills which runs along lake Superior is variable in width, ranging from forty to seventy miles, and its eastern extension assumes on the north side of lake Huron a width of about fifty miles. Behind the rocky elevated range referred to the surface is found to be comparatively flat. Between the province of Manitoba and lake Superior the drainage of the country is mainly westward, passing into lake Winnipeg. The water shed between the two lakes is quite close to lake Superior and maintains a nearly uniform elevation of from 1,400 to 1,500 feet, while lake Superior is 600 feet and lake Winnipeg 710 feet, above the sea. The descent from the watershed westward is very gradual, and the country for the whole distance is remarkable for the innumerable streams and lakes with which it is intersected. These consist of long, winding sheets of water, separated by rocky ridges; and so numerous are they that an Indian in his canoe can travel in almost any required direction by making an occasional portage. Lake Nepigon lies directly north of lake Superior, and discharges into it by the river Nepigon. The descent to the latter lake is 252 feet. Lake Nepigon is the most northerly reservoir of the St. Lawrence basin, the brim of which is here extended 120 miles north of lake Superior. The outline of the watershed is however so irregular that a few miles to the east of lake Nepigon the brim of the basin curves round until it reaches a point within 20 miles of lake Superior North of this point the waters flow towards Hudson bay. Although the general aspect of the country east of lake Nepigon as seen from lakes Superior and Huron is precipitous and rugged, to the rear of this wild and rocky frontier the surface descends northerly in easy slopes. So much is this found to be the case, that in passing from lake Nipissing to lake Nepigon, through the interior of the country, the ascent to the summit level will actually be less than that which is experienced in passing from Toronto across the peninsula of western Ontario by either the Great Western, the Grand Trunk, the Grey and Bruce, or Northern railways. The drainage of the flat country referred to as existing between the Nepigon basin and the Ottawa valley flows northerly by the rivers Albany and Moose to James bay; while the drainage of the rugged, elevated belt along lakes Superior and Huron passes into the basin of the St. Lawrence. The agricultural resources of this extensive region of country are not promising. But the timber which covers its surface will every year become more and more valuable, and its geological structure affords indications of mineral wealth."[5]

Engineeer Rowan's report.

Mr. James H. Rowan, C.E., was in charge of the surveys in the Woodland division, and in reporting to Mr. Fleming under date of 5th June, 1873, on the success which had attended the efforts to locate a line of railway from the vicinity of lake Nipissing to Red river, on which neither the amount of excavation and embankment, the bridging, the grading or the curves would be exceptionally heavy, he remarks as to the general character of the country:

"Attention to the particular work on which they were engaged left little time for other explorations at the disposal of the various parties. It may be stated however that the country traversed gave indications, at many points, of the existence of iron, copper, gypsum, also of the more precious metals; and I think it is not improbable that coal or other mineral fuel may be found, if not immediately on the line of railway, probably at no great distance from it in the country to the north. Sufficient timber for railway purposes can also be procured, and although a considerable portion of the land may be unfit for agricultural purposes, there are tracts of fair quality to be met with at various points along the line."[6]

Elevations.

A list of elevations above the sea of the principal lakes and rivers on the line is appended to Mr. Rowan's report, from which it appears that Sturgeon lake, west of lake Nepigon, is the highest point on the route, being 1,327 feet above sea level. It would seem therefore that Mr. Fleming put the figure too high when he estimated that the greatest elevation on the line north of lakes Superior and Huron might reach 2,000 feet above the sea.

SOME DETAILS OF THE WOODLAND DISTRICT.

From Rat Portage to the height of land.

Speaking of the Woodland division in detail, Mr. Rowan remarks that from Rat Portage east to the height of land, a distance of 230 miles, there is a rise in elevation of between 400 and 500 feet. A striking peculiarity of the country is the great extent of water surface, consisting of lakes and lacustrine streams of every conceivable shape and size, the former for the most part lying in the direction of the rocks, the latter occasionally cutting across it. The hills which almost universally follow a general direction from northeast to southwest consist chiefly of Laurentian rocks. Mr. Rowan noted evident indications of the whole country having been swept by intermittent fires. About 30 miles east of Rat Portage the line crossed a divide running easterly to the height of land. This divide throws some of the waters to the south through the Winnipeg river, and some to the north into English river, the outlet of Lonely lake or Lac Seul, which joins the Winnipeg 50 miles below Rat Portage. There is a marked difference between the country on the south and that on the north of this divide. The former is extremely rocky and rugged, while the latter is more level, with extensive tracts of light sandy soil.

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[5] Report of Progress on the Explorations and Surveys, Canadian Pacific Railway, up to January, 1874, by Sandford Fleming, Engineer in Chief, pp. 8, 9.

[6] Ibid. p. 158.

Lake Nepigon district.

Lake Nepigon is the most prominent feature in the country to the east of the section just described. It is some 70 miles long by 50 miles wide, and contains many islands. The descent from the height of land to this body of water is much more rapid than the ascent on its western side, falling some 900 feet in a distance of about 50 miles, and as a consequence there are fewer lakes than in the region to the west. The character of the hills is also changed. Here they are more detached, very precipitous on their northern and western sides, and standing at a greater altitude above the general level of the country. Their general direction is also different, inclining from north and south to northwest and southeast Lake Nepigon discharges into lake Superior by the river Nepigon, and a little to the west the Black Sturgeon takes its rise in the lake of that name and also adds its volume to that of the great fresh water reservoir. Both these rivers are of considerable size, and in their valleys are large tracts of good land and timber of fair quality, consisting of spruce, tamarack, cedar, pitch pine and a sprinkling of white and red pine. From lake Nepigon to Long lake the country maintains the same general character, rising rapidly until the height of land is again crossed in the neighborhood of the latter lake. A divide runs east from the southern end of lake Nepigon separating the waters flowing south into lake Superior from those which run northward, but which ultimately find their way into the same place through the valley of the Nepigon. To the south of this the country is very rough and rocky, and is cut through by the valleys of rivers running from north to south having their sources in the height of land. On each side of these rivers the hills rise from the water's edge steep and precipitous to a height of 400 to 600 feet near lake Superior.

On Albany river.

The country lying between lake Nepigon and the Albany river consists of Laurentian gneiss and granite, alternating with Huronian schists, and as far as exploration has disclosed contains good land only in isolated tracts of small extent. Gneiss prevails on the Albany down as far as the most northern point of the great bend of that river, some distance below Martin's Falls, at which point yellowish limestone strata make their appearance. Lower down these are overlaid by drab and chocolate colored marls and shales. The fossils found indicate the Niagara formation. Martin's Falls is only a rapid with a descent of about 12 or 15 feet, down which light canoes are easily run. From this point to James bay the river is open on an average six months of the year. Hay, turnips and potatoes have been successfully cultivated at the Hudson Bay post here for a long time, and cattle thrive well. Fragments of a hard, banded hematite containing usually about 50 per cent of iron occur in the drift along the Albany. Below Martin's Falls the country on both sides of the river is quite level. The banks are steep and from 40 to 90 feet high. They drain a narrow strip of land on either side, but beyond this great swamps appear to extend.

Valley of the Kenogami.

Dr. Bell says of the valley of the Kenogami, a tributary of the Albany which takes its rise in Long lake, twenty miles only to the north of lake Superior: "The English or Kenogami river flows through a level country all the way from Long lake to the Albany. Some ridges and knolls of syenite and gneiss occur at intervals, in the upper part of its course; but even these disappear below Pine lake, and the whole surface becomes uniformly level. Banks or terraces of brown loam and gravelly earth, varying from ten to about forty feet, but averaging about twenty in height, occur nearly all along the sides of the river, as far as we explored it, and also around Pine lake. In rapid parts, these terraces approach close to the water's edge; but at other places they generally recede, on one side at least, a short distance from the river. The soil on the top of the banks, and to some distance from the river, appeared very good in most of the localities examined. The timber consists mostly of spruce, balsam-fir, white cedar, tamarack, white birch and aspen. Some of the larger spruces and tamaracks measured between five and six feet in girth at five feet from the ground; but the average diameter of the larger trees would be about eighteen inches. In the last twenty or thirty miles explored, the ground became swampy on going back to a short distance from the river on either side, the timber consisting of small spruces, cedars and tamaracks. The Indians report the same conditions to prevail over a very large area in this section; while nearer James bay the ground is still lower and more swampy, and is interspersed with large and very shallow lakes, and with bogs and marshes, in which great numbers of water fowl breed in security, their haunts being inaccessible, either on foot or by canoe. Some of the bogs are said to be so wide that one cannot see across them, and the only objects that break the outline of the horizon are a few stunted black spruces, standing far apart."[7]

General features of the country between lake Superior and Albany river east of lake Nepigon.

"In a general way," Dr. Bell sums up with reference to the district lying between like Superior and the Albany river, "it may be said that the whole country examined north of the hilly region around lake Superior and east of lake Nepigon, is comparatively level, with a sandy soil, generally dry, but in places interrupted by shallow swamps and low rocky ridges. The soil appears to be for the most part naturally poor, and over a considerable proportion of this area it has been rendered worse by the burning out of the vegetable mould by repeated fires. The old timber consists in order of abundance of spruce, balsam fir, tamarack, white birch, aspen, white cedar, Banksian pine or cypress and balsam poplar; but after the fires the new growth consists principally of white birch and aspen. . . . The climate appears to be no worse than that of parts of the province of Quebec which are already inhabited. In going from lake Superior to the valley of the Albany no difference was observed in the character of the vegetation, which may be accounted for by the greater elevation of the southern part, together with the cooling influences which lake Superior exerts upon it. Oats and barley have been successfully cultivated at Long Lake House, while hay, potatoes, and all the ordinary vegetables thrive remarkably well. Last year the potato tops had not been touched by frost up to the time of harvesting, which was during the first week in October."[8]

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[7] Geological Survey Report 1870-71, pp. 340-41.

Along the Ogoké river.

The largest branch of the Albany river from the south side above the Kenogami is the Ogoké, which is described by Dr. Bell as averaging where examined by him about 500 feet in width, with large lagoons and marshes on either side, and from 50 to 60 feet deep in the middle. He was informed that it maintained the same dead water character for a long distance both above and below this point, and that in consequence it was well adapted for steamboat navigation on this part of its course, but he understood that it spread out to a great width and became very shallow after it reached the palæozoic rocks farther down.

The district from Long lake to the Ottawa river.

Of the country stretching from Long lake to the Ottawa river across the several tributaries of the Moose, the section south of the height of land is more forbidding in its general aspect than that lying to the north. In many places the lofty hills of primitive rock have been swept bare of every trace of vegetation by fire, and present a most formidable and dreary appearance. The northern section is in marked contrast to all this; at a short distance north of the height of land the country becomes level and in some places swampy, the latter characteristic, perhaps due in part to the dense growth of timber which covers it, fires having been much less frequent in this section. There are many tracts of fair land in this northern slope, and there can be little doubt that were the country cleared and drained, the effect on soil and climate would be as marked as it has been in the settled parts of Ontario. But even in the region which drains into lakes Superior and Huron there are many areas of cultivable land, notably in the valleys of the rivers, and if there were a general demand for it there can be little doubt that the sharpened eyes of land-hunters would discover that numerous sections now deemed unfit for settlement have a soil capable of supporting a thrifty and industrious population. A very large portion of the country through which the Canadian Pacific line was originally projected is covered with a dense growth of moderate sized timber, consisting of balsam, spruce, poplar, white birch, some tamarack and occasionally groves of white and red pine, and at many points indications of valuable mineral deposits have been observed.

LATER SURVEYS BY C. P. R. ENGINEERS.

From lake Nipissing to the Mattagami river.

In 1880 several surveying parties were again at work in the interest of the Canadian Pacific Railway trying to locate a line from the Southeast bay of lake Nipissing to Port Arthur (then Prince Arthur's Landing) which would be more favorable than any previously explored. Mr. W. A. Austin had charge of the eastern section, from lake Nipissing to the Mattagami river, a distance of 116 miles. Beginning at the east end, he says that in the first seventy miles some good land but not of any great extent was gone over, the surface being rocky and hilly. From the seventieth mile the land was more level, now sand, sand and gravel, and sandy loam, with swamps in various places. A small area of good land was found near Mattagami lake. The timber of the first half of the line was chiefly white pine, spruce, birch, tamarack, balsam and maple; of the latter half spruce, pitch pine, white and red pine, balsam and some tamarack and maple.

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[8] Geological Survey Report 1870-71, p. 350-351.

From the Mattagami river to the Moose.

The next section west from Mattagami river to the Moose, about 116 miles, was explored by Mr. O. H. Gamsby, who divided the ground into four sections from west to east.

(1) From the Moose to the Kapaskasi river.
(2) From the Kapaskasi to the Nestodjiostone river.
(3) From the Nestodjiostone to the Ground Hog river.
(4) From the Ground Hog to the Mattagami river.

Section 1, about 32 miles long and from 30 to 60 in width, was composed largely of a clayey loam surface mixed with vegetable mould, identical with the soil in the vicinity of New Brunswick House where fine crops of coarse grain and roots had been grown the previous season. Fully seventy per cent. of the soil in this section could be classed as very good.[9] The remaining thirty per cent. is composed of about ten per cent. inferior, the rest being small muskeg and gravel ridges. Timber, chiefly birch, poplar, cedar, spruce and tamarack is found in great abundance, and in many localities of large size, the cedars being particularly fine. Section 2, which was twenty-two miles long and of less width than section 1, was broken by high granite ridges. The clay and marl soil only occur in belts, being in the interval replaced by sandy loam mixed with boulders. Perhaps fifty per cent. of the soil would rank as good, the remainder, though not worthless, would be classed as inferior. A considerable part of this section had been burnt over, and timber was found only in the swamps in such portions. In the unburned areas a moderate quantity of white pine was found mixed with the varieties prevailing in section 1. No muskegs of any size occur in this section. Section 3, about sixteen miles in length, had a fair proportion of clay soil extending from Nestodjiostone river four miles southeasterly to the Pishganagamee. In the rest of the section the soil was sandy, with boulders, though Mr. Gamsby found good crops of barley and roots growing at the

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[9] A subsequent examination in 1885 by Mr. Borron convinced that gentleman that Mr. Gamsby's estimate was much too high. Dr. Bell's impressions of the district near this locality are thus recorded in the Geological Survey report, 1877-78, part C. pp. 7-8:

"But after passing the swampy grounds north of Missinaibi lake, the traveller cannot fail to be struck by the abundance and the general fertility of the soil exposed in the banks of the Missinaibi and Moose rivers all the way to Moose Factory. It consists mostly of a brownish, somewhat gravelly loam or earth, resting upon till, and sometimes upon stratified clays or the solid rock, which, however is seldom seen except at the principal rapids and falls. But in the central third of the section between lakes Superior and James bay, or from the Brunswick to the Long Portage, a light colored clay usually forms the surface. I examined the country for a mile or two back from the river in several places for the special purpose of ascertaining the nature of the soil, and found it excellent in all cases, but tending to become more swampy in receding from the river in the Devonian region below the Long Portage. Samples of the soil were collected in a few places for subsequent examination. In traversing such a great extent of almost unbroken wilderness, one is apt to forget the possible value of this vast region for agricultural purposes. But the examples of the farms at New Brunswick House and Moose Factory show, upon a small scale, what might be extended over a great part of the country. I have no doubt that at some future time this territory will support a large population."

Hudson's Bay Company's post at Groundhog lake. The timber of this section was very similar to that of number 1, except that red pine took the place of spruce. Considerable quantities of red and white pine of good size were found throughout the whole of this section. Section 4, forty-four miles long, was higher and more broken than any of the others, and displayed a good many rocky ridges. The soil was sandy loam with boulders, and may be classed as inferior. There was a great abundance of red pine growing in this section. It was tall, straight and sound, varying from four to fourteen inches in diameter ; probably not up to the standard for lumber for exportation, but of great value for domestic uses and occupations."[10]

BORRON'S CONSERVATIVE VIEWS.

Classes of farm land south of James bay.

Mr. Borron is perhaps more inclined than any of the other explorers to speak with reserve as to the general suitability for agricultural purposes of the Hudson Bay slope. Referring to a large portion of the central plateau lying between the Missinaibi and Kapuskasing rivers examined by him in 1885, and covering part of the territory described by Mr. Gamsby, Mr. Borron says : "I do not think we should be safe in assuming that more than one-third is arable in any reasonable sense of the term"; but he adds that nevertheless there is a large proportion of the land which has a good soil, and will be valuable for hay and pasture, if not also for root crops. According to Mr. Borron, in the flat country south of James bay, underlaid by the Devonian limestone, there are three classes of agricultural or pastoral land : (1) The strip immediately adjacent to the waters of James bay, from a quarter of a mile to three or four miles in width, on which there is naturally fine pasture and much marsh hay. A large number of cattle could be supported on this strip. (2) The low-lying bottoms, points and islands of alluvial soil found at intervals on the rivers in the territory. The land is good, but generally flooded in the spring, and while of considerable extent in the aggregate, rarely occurs in blocks of sufficient size to form a large settlement. (3) A narrow strip along the margin of the rivers, varying in width from a quarter to half a mile. Back from the rivers it is Mr. Borron's opinion that the whole country from the Abittibi on the east to the Albany on the west, and extending many miles inland from James bay is a vast level clay plain overlaid almost everywhere by peat bogs of very extraordinary extent. In the region to the south of this flat country, and intermediate between it and the height of land, is the belt of land characterized by numerous rapids and falls in the rivers which traverse it. While there is in the aggregate a large quantity of arable land, principally clay, and a much larger area still that would form fine pastures and meadows, Mr. Borron's explorations have lead him to believe that muskegs or peat mosses overspread the greater part of this section also. In the height of land region itself Archæan rocks constitute a large proportion of the surface, and frequently rise into low ridges or hills. Between these are lakes, marshes and swamps. The soil on the ridges is rarely clay, but is generally light and stony in character. A small proportion only of the land is suitable for grain growing, but nearly all of it will afford more or less pasture. The area occupied by peat mosses is relatively small compared with that covered with timber. The wetness of these plains, in which the soil is almost universally clay or underlaid with clay, and which the natural drainage system is insufficient to remedy, appears to Mr. Borron to be the principal cause of the formation of these great bogs. The depth of the main rivers below the level of the adjacent country is very slight, and their tributaries are consequently short and of no great volume. As a consequence, the surface at some little distance inland remains permanently wet, thus providing, in conjunction with the northern climate, the most favorable conditions for the growth of the sphagnum moss which forms the bulk of these peat marshes. An extract from Mr. Borron's report of 1880 gives a graphic description of the peat country, and at the same time utters a warning against judging the interior region from the land and vegetation seen along the river routes.

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[10] Dom. Sess. Papers, 1880-81, Vol. XIV., No. 23, p. 12 *et seq.*

The peat country.

"The traveller, visiting Moose Factory for the first time, following the usual routes, and seeing so much only of the country as may be visible from his seat in a canoe, is almost certain to form too favorable an opinion of the character and the resources of the territory north of the height of land. The fertility of the soil, the size and healthiness of the timber, and the luxuriance of the native grasses, as seen in many places on the banks of the rivers, inevitably tend to the belief that this is the general character of at least the adjacent land. A more thorough examination of the region thus travelled through has convinced me that the quantity of arable land fit for settlement is not nearly so great as I had supposed it to be. Those who have read the preceding narratives of my explorations this season cannot fail to have perceived that the fertile appearance of the land on the immediate banks of the rivers is very delusive and misleading. Over and over again it must have been noticed that on going inland at those points where on the banks of the rivers the soil and timber presented the most promising appearance, we found that the ground became wetter and wetter, that sphagnum moss covered the surface to a greater and greater depth, and that generally in less than half a mile we came to where peat had been formed; that as these peat mosses increased in depth, first the poplar, aspen and birch would give place to spruce, and to what is called in this country juniper or tamarack; and secondly, these last would diminish in size until they were little more than mere shrubs thinly scattered over the widespreading surface. Nor were these trees healthy wherever the peat had attained to any considerable thickness. On the contrary, they were not only stunted, but scrubby, and frequently dead. They were draped, too, with a species of parasitic hair-moss of a gray or black color, which hung in long dishevelled tresses from the dead and dying branches, and imparted to the whole scene a most dismal and funereal appearance."[11]

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[11] Report on the Basin of Moose River, 1890, pp. 8-9.

NEW REGIONS OPENING FOR SETTLEMENT.

A fertile belt in the Rainy River basin.

In the valley of the Rainy river at the extreme western end of the Ontario Hinterland there is a fertile belt of rich alluvial soil greatly in contrast with the peat wilderness just described, the extent of which is variously estimated at half a million to four million acres. The latter figure no doubt includes the agricultural land of similar character on the banks of the Seine and other streams emptying into Rainy lake and on some of the rivers flowing from the east into Lake of the Woods. A number of towships on Rainy river were surveyed into farm lots by the Dominion Government when the territory was in dispute and some have since been laid out by the Ontario Government, and the land has been opened for settlement under the Free Grants Act. The timber of the district includes pine, poplar, birch, basswood, oak, elm, ash, soft maple, balm of Gilead, balsam, spruce, cedar, and tamarack, and a considerable business is done in rafting logs down the Rainy river from Rainy lake and its tributaries. The drawback under which the section has so far labored is lack of railway communication, for want of which it is practically isolated in the winter months. Notwithstanding this, a prosperous settlement is being formed, and the recent discoveries of gold in the country around and north of Rainy lake are likely to give it an impetus by providing a ready and nearby market for the agricultural products of the valley. It is a happy combination of circumstances when mining and agriculture can be carried on alongside each other. A population engaged in mining has usually little opportunity or inclination to till the soil, even if the surface of their rocks were more propitious than it generally is, and consequently there is an unceasing demand for the very articles which the farmer produces from his land, for grain and flour, for beef and pork, for butter and cheese, for milk and vegetables. Indeed there is no better market than a mining camp for everything grown on a farm, and no one is more willing to pay a good price for what he wants than a miner earning good wages in a paying mine. The gold finds of the Rainy lake country are attracting a good deal of attention, and the rush this spring to the field is likely to be great. It is to be hoped that operations will be conducted not only with vigor, but with discretion, and that capital will not be thrown away in erecting costly plants before veins are thoroughly proven both as to extent and quality. Failures from this and similar causes have been too common in Ontario, and have helped largely in fastening upon the business of mining that reputation for risk and uncertainty which it holds to-day in the public mind. The fact that the gold in this district occurs largely in bedded veins, while by no means fatal or perhaps even prejudicial to ultimate success, should be an additional reason for carefulness. It Rainy lake should take the place among the gold producing fields of the continent which sanguine men anticipate, the future of the agricultural belt along the Rainy river is likely to be a prosperous one.

Agriculture and mining.

A fertile area at Wabigoon lake.

It is almost invariably the case that a close examination reveals a much larger proportion of good land in a new district than had been accorded to it at first glance. This has had a recent illustration in a part of western Ontario traversed by the Canadian Pacific Railway. When that line was first opened the general verdict of travellers from Port Arthur to Rat Portage was that the whole country was a barren stretch of rock and swamp. It is now being found that such is by no means the case. In the vicinity of Wabigoon lake, north of the height of land, there has been found a tract of excellent clay land extending over an area equal to that of three or four townships. The Government of the province is taking steps to prove the capabilities of the district by establishing a pioneer dairy farm near Barclay station, on the north side of Wabigoon lake and about the centre of the fertile area. A market will be found in the dining cars of the Canadian Pacific Railway for all the milk, butter and cream that can be raised on the farm, and the likelihood is that the supply will fall short of the demand, for there is a long reach of unsettled country on both sides of Barclay, and hungry passengers must be fed. There is a considerable water power on the Wabigoon river, which flows out of Wabigoon lake and joins the Eagle river, the outlet of the lake of the same name, after which the mingled waters flow into the English river and so into the Winnipeg; and this water power may yet be used for saw-milling and other manufacturing purposes.

The Lake Temiscaming district.

Turning now to the eastern extremity of the province, we find a district probably quite as fertile and at present more accessible than that of the west. From the mouth of the Montreal river, about thirty miles south of the head of lake Temiscaming, northward across the height of land to lake Abittibi, and it is believed by some even to the shore of James bay itself, stretches a vast level clay plain, broken here and there by protruding gneissoid and dioritic or slaty rocks.[12]

In the region north and northwest of lake Temiscaming some twenty-five townships have been laid out and surveyed by the Department of Crown Lands in and adjacent to the valley of the river Blanche, and it is thought that a cultivable area of at least half a million acres, and probably more, is to be found here in one continuous block. Over a sub-soil of rich, calcareous clay a covering of vegetable mould many inches deep has accumulated, the whole being of exceptional fertility. The labor of clearing the land for the plough is rendered light by the comparative smallness of the timber. A very large quantity of spruce grows here suitable for pulpwood, and there is great store of cedar which attains an unusual size. The whitewood of the lake Erie counties reappears here, and oak, birch, elm, sugar maple and hemlock are also found. A demand is springing up for the lands of the Temiscaming district, and access will be greatly facilitated by the line of railway being built by the Canadian Pacific on the Quebec side from Mattawa up the Ottawa river to the foot of the lake, a distance of about thirty miles, for the purpose of overcoming the rapids *en route*.

It is not to be supposed that the districts which have been mentioned are the only ones in which good land occurs, for there are many others in which it is known that there are considerable tracts of a rocky, swampy, or otherwise broken character, but yet containing a sufficient area of cultivable soil to support a large population

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[12] An interesting fact is that at the north end of the lake a fossiliferous limestone appears in places, which seems to correspond to the Niagara formation. The denudation of this limestone may in part at least have given rise to the white clay deposits of this district.

TIMBER OF THE HINTERLAND.

The home of the pine.

Hardly less important than the land itself is the timber which it bears, and the timber wealth of the Ontario Hinterland is varied and great. The principal forest tree and the one with which as yet the lumbering industry chiefly concerns itself is the pine. The home of the pine in Ontario is the Ottawa valley, including the various districts drained by its tributaries, and the country contiguous to Georgian bay and lake Huron. Very extensive groves of white pine (*P. strobus*) and red or Norway pine (*P. resinosa*) originally stood in these sections, disputing the territory with other conifers and the deciduous trees; but bush fires, the arch-enemy of American forests, and the lumberman's axe have made serious inroads upon them. A chief seat of the lumber trade is in the country north of lake Huron, on the French, Sturgeon, Wahnapitae, Vermilion, Spanish, Sable, Serpent, Blind, Thessalon and Mississaga rivers. The pineries here were on a very large scale, and are by no means yet exhausted, though the yearly cut of logs is being brought from farther and farther up the streams. There is however a large quantity of pine to be brought out of the country north of lake Huron. Between the Canadian Pacific Railway main line and Sault Ste. Marie there are considerable tracts of pine not yet brought into the market. The north shore of lake Superior appears to be largely devoid of merchantable pine, but farther west on Rainy lake and Lake of the Woods and in the country to the north and east of these lakes respectively, pine of good quality is now being taken out, though it is of smaller size than that of the east. The rivers running into lake Temiscaming from the Ontario side are important lumbering streams. Large areas of valuable pine still belonging to the Crown are known to exist north of lake Wahnapitae and west of lake Temiscaming, and it occurs plentifully on the banks of lake Temagami and Rabbit lake. While in a general way it appears to be true that the northern limit of the pine in the eastern portion of the province is the height of land, there is little doubt that in the aggregate a considerable quantity is found in the more southerly reaches of the Hudson bay slope. The timber here however does not at present form part of the available supply for lack of means to convey it to market. It is impracticable to float it down stream to the north, and it cannot be brought south until a railway is built. White pine is abundant and of good size on all the head waters of the Moose, and red pine exists farther north than the white. From the Missinaibi westward to the Albany river pine seems to be confined to a few groves of the red variety of no great extent or importance. Between the height of land and the 49th parallel considerable red and white pine are found growing on the ridges. Red pine is frequently met with singly or in clumps on the islands and shores of lake Opazatika, which seems to be on the northern verge of its *habitat*. North of lake Temiscaming white and red pine are found as far as lake Abittibi, though at the latter place the trees are small and scraggy. On the slopes of the hills along both sides of the height of land in this locality pine is abundant and of good quality. At lake Matawagogig on the northern slope of the height of land, pines eight and nine feet in circum-

Seats of the lumber trade.

Pine areas of the far north.

ference have been noted, and groves of white pine occur in all directions. According to Dr. Bell red and white pine are common all the way from lake Huron to Mattagami lake, and ceased to be observed a short distance below Kenogamisee lake.

Jack pine.

The jack or Banksian pine is a scrubby tree in its southern extension, but is larger and more important in the north, as in the region of the Albany river, where large groves occur in which the trees are about seventy feet in height and two feet in diameter at the butt, with straight trunks nearly free from branches for the first twenty or thirty feet.

Spruce.

The most northerly tree of the continent is the spruce, which is found in greater or less abundance from the great lakes to James bay, and from its plentifulness and the uses to which it can be put, is probably the most valuable tree north of the height of land. It attains good size for lumber purposes in the neighborhood of James bay. "The original timber along the lower stretch of Moose river" says Dr. Bell, "has been mostly burned within the last fifty or sixty years, but wherever the old spruces have escaped they are of larger growth than those seen on any other part of the route from Michipicoten." According to Mr. Charles G. Horetzky of the Ontario Public Works Department, who was twenty-six years ago in the employ of the Hudson's Bay Company at Moose Factory, there is considerable spruce of fair size on the banks of the Moose river thirty or forty miles from its mouth. Specimens three feet in diameter are sometimes seen. The Hudson's Bay Company were at that time in the habit of getting out one raft of spruce timber every autumn containing several thousands of feet which they sawed into lumber at Moose Factory for building and other purposes. But the bulk of the spruce growing on the muskegs or peat mosses on both sides of the Moose is of stunted growth and unsuitable for manufacturing into timber. "There is no tree however" says Mr. Borron, "which possesses in an equal degree the power of adapting itself to all the changes of soil and climate in this northern territory as the spruce. It is consequently the tree most commonly met with from the moment we cross the height of land until we arrive at the coast of James bay. On the rich soil of the sheltered river bottoms it overtops all the other trees, and attains a circumference of from six to eight feet. On the coast and islands of James bay it still holds its ground, but is greatly dwarfed, the largest trees on Charlton island being less than half the size of those just referred to. . . In the aggregate there is an enormous quantity of spruce of useful sizes in this territory."[13]

Valuable timber for paper pulp.

Spruce is also found in the Temiscaming country and on the rivers flowing into lake Huron from the north, whence considerable quantities in the form of 4-foot lengths are every year exported to the paper factories of the United States. On several of the rivers tributary to lake Superior it grows in some quantity, and is there cut for the same purpose and sent to the same market. Spruce is the most desirable tree for pulpwood, the next in favor being the poplar, and the rising demand is adding every year to the value of the spruce growing in Ontario. It has enabled the Department of Crown Lands to begin the process of turning to account such tracts of this timber as exist on the ungranted lands of the Crown by disposing of the right to cut over specified areas. Should the pine forests of the province in time begin to fail under the great and constant demands made upon them and consequently cease to yield to the public revenues the large amounts which they have been and are now producing, it is worth considering whether the spruce forests of northern Ontario cannot in some degree at least be made to take their place.

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[13] Report on the Basin of Moose River, 1890, p. 46.

Tamarack,

The American larch, or as it is more commonly called, the tamarack, is widely diffused through the whole territory both north and south of the height of land, and in point of abundance probably ranks next to the spruce. To the south and west of James bay, it is found of largest size on the dry uplands and where there is good soil, but smaller trees are plentiful in the swamps and peat mosses. The tamarack grows plentifully in the neighborhood of lake Temiscaming. Along the line of the Canadian Pacific Railway there is a demand for this timber for use as railway ties.

poplar,

hemlock,

white cedar

and other trees.

The balsam poplar grows luxuriantly along the rivers flowing into James bay, and attains considerable size in the neighborhood of lakes Huron and Superior. The common poplar or aspen, largely used as fuel in Manitoba and the Northwest territories, is valued next to spruce as raw material for the manufacture of paper. It is common on the height of land, but particularly on the northerly plateau and the banks of the rivers which traverse the great plain further north. The hemlock is found round lake Temiscaming, but does not appear to occur in any frequency throughout the district spoken of. White cedar grows in the country south of Moose Factory and the Albany river, and is of large dimensions in the vicinity of lake Temiscaming. Of the deciduous trees, maple, oak, elm and ash occur in places south of the height of land and rarely on the Hudson bay slope.

PEAT AND ITS USES.

Extent of the bogs,

and various uses of peat.

The peat mosses described by Mr. Borron are estimated by him to occupy an aggregate of 10,000 square miles. While undoubtedly detracting from the agricultural capabilities of this region, very materially these great peat beds have a value of their own. It is not improbable that in the absence of a good quality of coal prepared and pressed peat fuel may come largely into use in Ontario, and if means of transportation are afforded, an inexhaustible source of supply will be opened up in this northern territory. Recent improvements of manufacture give ground for hope that we may soon be put in possession of a really efficient and economic fuel produced from peat. The value of peat as a deodorizer is also coming to be recognized, and in disposing of sewage and waste matter without offense it finds much employment in the cities and towns of continental Europe. In the form of moss litter it is used with great success as bedding for horses and cattle owing to its capacity when dry of absorbing as much as twenty or twenty-five times its own weight of moisture. When its use in the stable is ended, it is in condition to be employed as a fertilizer of the highest value. Peat also provides raw material for textile fabrics, and is employed as a preservative packing for fruit and perishable articles.[14]

MINERAL RESOURCES OF THE HINTERLAND.

An imperfectly explored region,

The mineral resources of the Hinterland are as yet but very imperfectly known. The prospector has been abroad in the region skirting the great lakes, and in that traversed by the Canadian Pacific Railway, and many important discoveries have been made. But even here only a small proportion of the country has been examined with anything like minuteness, and every year is bringing fresh deposits of mineral to light. What the interior of the country may disclose time only will tell, but there is no ground for believing that all the mineral wealth of Ontario is confined to the southern region. Among the earliest mining operations on a large scale in the province were the works carried on at the Bruce mines, on the north shore of lake Huron, where upwards of $3,000,000 worth of copper was extracted between 1846 and 1876. The celebrated silver mine at Silver Islet in lake Superior proved extraordinarily rich, and from a little space scarcely bigger at the surface than a ballroom about $3,250,000 worth of silver is believed to have been taken until the mine was abandoned in 1884 at a depth of 1,230 feet About the year 1878 gold was found on Lake of the Woods, and subsequent exploration has made known an extensive area of gold-bearing rock in this region. The silver mines of the Rabbit and Silver Mountain districts were discovered in 1882, and were worked with success until the falling price of silver rendered them unprofitable. The sudden springing into prominence of the Sudbury copper-nickel mines is a notable feature in the history of mining in Ontario. The opening of these deposits was a direct result of the construction of the Canadian Pacific Railway, the first body of ore having been laid bare in 1882 by a cutting on the main line where is now situated the Murray mine of H. H. Vivian & Co. It was not until after the mines had been worked for some time that the presence of nickel was suspected in the ore. Now the Ontario mines contest with those of New Caledonia the supremacy of the world's nickel market. It is asserted that one Canadian company contributed as much as seventy per cent. of the total output in 1894. The manner in which the nickel ore occurs and the process of working it are well known, and do not require description here. With the increased demand which is sure to follow the extended use of nickel in the arts, a period of even greater activity and prosperity for the nickel mines of Ontario may be looked for. Gold was found in some quantity north of Bruce mines on the location now owned by the Ophir Mining Company, and in the autumn of 1893 the promising gold belt of the Rainy Lake country was first brought to the attention of the

yet many valuable discoveries made.

Bruce mines.

Silver islet.

Lake of the Woods.

Rabbit and Silver Mountain.

Sudbury.

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[14] For a fuller account of the peat deposits of Ontario and elsewhere and their utilization for fuel and other purposes, see First Report Bureau of Mines, p. 180, Second Report, p. 195, and Third Report, p. 139.

public. This district was the scene of considerable activity last summer, and a good many finds of greater or less promise were made. The present spring bids fair to witness a rush to this latest of the gold fields of the continent.[15]

Galbraith and Rainy lake.

Some very rich samples of gold-bearing quartz have come from the vicinity of lake Wahnapitae, and it is quite possible that that locality may yet see gold mining operations being conducted on a considerable scale. All the gold hitherto found in Ontario has been in place and not alluvial. Rumors of placer fields are heard from time to time. Sometimes they are located on one or more of the rivers emptying into lake Huron; sometimes they are spoken of as existing near the height of land, and the latest is said to be at Shoal lake on the Seine river, a tributary of Rainy lake. If anything tangible is really known of these alleged gold diggings, the possessors of the information have seen fit, not only to keep the knowledge secret, but to make no use whatever of it themselves. The copper-bearing rocks of the south shore of lake Superior have their counterparts on the northern side, and at Point Mamainse deposits of native copper and copper ore have long been known to exist, and indeed were exploited to some extent many years ago. Exploratory work has recently been resumed, and has satisfied the proprietors that the property is likely to be a very productive one. Copper also occurs in considerable quantity on Michipicoten island Very extensive deposits of excellent magnetic iron are known to exist at Gunflint lake on the boundary between Ontario and Minnesota, on Hunter's island, on the Mattawin and Atik-okan rivers and elsewhere west of Port Arthur. North of lakes Superior and Huron iron is also found.

Lake Wahnapitae.

Point Mamainse.

Iron ores.

HURONIAN AREAS AND THEIR MINERALS.

The azoic rocks of northern Ontario, comprising the Laurentian and Huronian systems, occupy so far as yet known, almost the entire space between the great lakes and the southern boundary of the palæozoic formations inland from James bay. The Laurentian has long had the reputation of being comparatively barren of minerals, while the Huronian is regarded as pre-eminently the system in which mineral deposits may be looked for. With the exception of the silver veins west of Thunder bay and the copper of Point Mamainse and Michipicoten, which are respectively in the Animikie and Nepigon formations, the two lowest members of the Cambrian system, the mineral deposits above referred to are found exclusively in Huronian rocks. The great Huronian belt extends eastward from the south-

Belts of the mineral bearing Huronian formation.

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[15] The existence of gold and other minerals on Rainy lake was known previous to 1890, as will be seen by the following extract from the evidence of John McQuarrie in the Report of the Commission on the Mineral Resources of Ontario, published in that year (p. 64). "There are some fine specimens of gold, iron, and silver on Rainy lake. Mr. Alex. Baker, of Fort Frances, has some splendid specimens of gold and silver which he claims came from there, and also lignite. They were found on the north shore of Rainy lake. Mr. Thomas Sheppard also had specimens. The quartz was claimed to be gold-bearing although it does not show free gold, and on analysis there proved to be considerable silver as well. Several specimens have been brought in by Indians, but they want money before they will tell where the deposits are."

east corner of lake Superior along the north shore of lake Huron, and thence northeastward to the provincial boundary at lake Temiscaming, embracing within its limits the copper deposits of Bruce mines, the gold of the Ophir mine and lake Wahnapitae, and the copper-nickel ores of Sudbury and vicinity. Huronian areas also stretch across all the branches of the Moose river, northward from the Montreal river to beyond lake Abbittibbi, along the Groundhog river and lake Mattagami, and around Michipicoten at the northeast angle of lake Superior running west and north, and extending inland to Dog lake. Other belts are those which stretch from the Pic river to Mattamasagami lake and westward to Nepigon bay, which run eastward from lake Nepigon to Long lake, and which occupy the basins of Rainy lake and Lake of the Woods. Another belt starts between these two last named lakes, and runs northeastward to and beyond the line of the Canadian Pacific Railway. Huronian rocks are also to be found at both ends of lake St. Joseph and along three sections of the Albany river, above the point at which the Devonian formation begins. The greater part of these areas is virgin soil to the prospector, and almost nothing is known of their resources; but it is reasonable to suppose that the same richness and variety of mineral wealth which characterize the Huronian formations elsewhere in the province will be found in these northern extensions of the same system. Large trap dykes are frequently found crossing the rivers and traversing the country for miles, and following the result of experience in other places, the prospector would probably find it of advantage to give such localities a thorough inspection. The researches of Dr. Bell and Mr. Borron, largely confined as they have been to the immediate neighborhood of the rivers and lakes, have made known a considerable number of mineral deposits of the bulkier and more easily recognized kind. So far as the rare metals such as gold and silver are concerned, it usually requires close research to discover them even when they are the immediate object of quest. Many sections of the province have been examined for their geology without suspecting the presence of valuable minerals afterwards discovered by the patient and experienced prospector.

A district of promise to the prospector.

THE PALÆOZOIC PLAIN.

Minerals of the palæozoic rocks on the Hudson Bay slope.

One practical difficulty that will confront the explorer on the Hudson Bay slope is the depth of overlying drift which conceals the fundamental rock from view over so considerable a portion of the territory. The southern edge or belt of the palæozoic plain has so far furnished the greater number of mineral discoveries, consisting as enumerated by Mr. Borron of lignite or brown coal, iron ore, kaolin or China clay, potter's clay, the finest of sand for glass-making, gypsum, fire-clay and brown and yellow ochres. Some indications have also been noted of petroleum and natural gas.

The existence of lignite on the Missinaibi or north branch of the Moose river, has long been known to the officers and servants of the Hudson's Bay Company. It outcrops at various points on the river from Big Rapids about half way between Moose Factory and the Long Portage, to Coal Brook some eight miles below Long Portage, the distance between the two points being by the river nearly 60 miles. At Big Rapids borings made by Mr. Borron in 1890 showed the bed of lignite to vary in thickness from two to four feet. It was unsatisfactory in quality, being composed principally of wood or tree trunks, imperfectly carbonized and a good deal mixed with sand. At Coal Brook Mr. Borron made as thorough an examination of the deposits as the time and tools at his disposal would enable him to do. He states the results he obtained in the following words: "The lignite and its associated clays which in 'coal measures' of greater age would be black shales are found in much thicker beds than I expected. They vary, as will have been seen, from one or two feet to nineteen feet in thickness. What proportion the coal bears to the shale in these beds, owing to the mixed condition in which the auger brought up the material of the different bands passed through, is left more doubtful than I could have wished, and only to be determined by a very considerable number of analyses of carefully taken samples. As a matter of opinion and judging from the appearance of what was brought up by the auger, I should say that in the deepest and apparently thickest beds not less than six feet or probably more than nine feet may be lignite coal."[16]

Lignite.

The quality of the lignite is ordinary. A sample brought from Moose river by Dr. Bell in 1875 and analyzed by Mr. Hoffman of the Geological Survey proved to contain about 46 per. cent. of fixed carbon and 39 per cent. of volatile combustible matter, with 12 per cent. water and 3 per cent. ash, and was pronounced very similar to the lignite of the Souris valley (Manitoba) and of the Blind Hills and Woody Mountains (N. W. T.) Lignite is also found on the Mattagami and Abbittibbi branches of the Moose, on the Albany river at its junction with the Kenogami and on the latter river itself. As to the area over which it occurs, Mr. Borron remarks, speaking of the Coal Brook deposits: "The establishment of the fact that these beds underlie at all events the greater part of these drift or glacial deposits, is, I think important in relation to the extent or area occupied by the lignite. Taken in connection with the existence of lignite on the Mattagami river under very similar circumstances, I am of opinion that there is probably a continuous belt of lignite-bearing country between these two points, which are about fifty miles apart, and that it may extend a considerable distance west of the Missinaibi and east of the Mattagami. . . . . I have no data to guide me in forming a reliable opinion as to the width of this belt, should it prove continuous between the points named, but I hardly think it will be less than ten or more than twenty miles."[17] Lignite is also reported to have been found on Lake of the Woods and Rainy lake.

Bituminous coal.

Some slight evidence has been adduced by Dr. Bell indicating the possibility of the occurrence of bituminous coal on the Albany river. On a small island below Martin's Falls he found in 1871 some loose fragments of a bright bituminous coal. He was informed by the Hudson's Bay Company officers that coal had never been brought into the country, and considering that the conveyance of even light and valuable goods is so expensive in this region, he says this is only what might have been expected. Dr. Bell accordingly concluded that the coal could not have been brought there by human agency. No coal beds, bituminous or other, or any areas of carboniferous rocks were seen or heard of, and though it is far from impossible these may exist, there is really nothing to warrant the belief that they do.

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[16] Report on Basin of Moose river, 1890, p. 68, 69.

[17] Ibid. p. 69.

Anthracite coal.

An impression has gone abroad, sometimes stated in very positive terms, that extensive beds of anthracite coal are to be found on the Hudson Bay slope or on the islands or shores of the bay itself. The alleged existence of these beds together with the great deposits of clay ironstone which are undoubtedly found, is sometimes urged as an argument for the construction of a railway to James bay. It would be a happy thing for the province if these areas of coal were real, but the present state of our information does not lead to this conclusion. The principal fact upon which the anthracite theory rests, so far as can be ascertained, is that Dr. Bell when at Moose Factory in 1875 was presented by an Indian with several specimens of a mineral having all the characters of a fine anthracite, except that it contained only a very trifling amount of ash. The specimens were said to have been found on Long island, south of the Great Whale river. Dr. Bell was also informed by a Hudson's Bay Company officer that the Indians had reported the occurrence of a similar mineral some miles inland from Little Whale river, and Mr. Low of the Geological Survey has obtained like samples in the interior of Labrador, many miles inland from Hudson's bay. No outlying members of the carboniferous series have yet been observed on the Hudson Bay slope, at any rate in Ontario; and although even their absence if demonstrated would not be in itself conclusive proof against the existence of coal, yet the evidence in favor of the occurrence of true coal is at the present time of the most meagre kind.

Iron ore.

A very large body of iron ore is found on the Mattagami branch of the Moose river at the foot of the Grand Rapid, about eighteen miles below the Long portage. The deposit is thus described by Dr. Bell: "Its position is on the northwest side of the river, at the foot of the rapids. It runs along the foot of the cliff for a distance of upwards of 300 yards almost continuously, with an exposed breadth of 20 to 25 yards. The highest points rise about 15 feet above the level of the river. The surface is mottled, reddish-yellow and brown, and has a rough spongy or lumpy appearance like that of a great mass of bog-ore. At the surface and sometimes to a depth of several inches, it is a compact brown hematite, occasionally in botyroidal crusts with a radiating columnar structure; but deeper down it is a dark-gray, compact, very finely crystalline spathic ore, apparently of a pure quality. The brown hematite evidently results from the conversion of the carbonate. The former yields according to the analysis of Mr. Hoffman, 52.42 per cent. of metallic iron, while the latter shows a very small amount of insoluble matter; indeed there is chemically little room for impurities, since it gives rise to so rich a brown hematite."[18] Mr. Borron adds his testimony from personal observation that the deposit is of large extent. He is satisfied "that any quantity of this ore can be obtained at a very low rate;" and that "associated as it is with lignite and peat for fuel it will unquestionably be mined and smelted on the spot at no very distant day." Mr. Borron also notes the presence of the same kind of ore *in situ* on the Oba river, about 20 miles above Mamattawa, and has observed indications of its presence on several other rivers. In his opinion it will be found when wanted in many places at or near the southern edge of the Palæozoic area. This is the sort of ore which is worked so largely in England and forms the basis of her enormous iron industry. A deposit of specular iron ore containing by analysis 39.41 per cent. metallic iron is mentioned by Dr. Bell as occurring on the east branch of the Montreal river. In the Nastapoka islands on the east side of Hudson bay and outside the limits of Ontario very extensive beds of carbonate of iron occur, carrying as high as 25 per cent. of carbonate of manganese—a valuable ore for the manufacture of spiegeleisen used in making Bessemer steel. The average thickness of the iron band, says Dr. Bell, is probably not less than 20 feet, and it appears to run through all the islands of the group, a distance of about 90 miles, exclusive of the more northern members which are more widely separated. The band is made up of layers a few inches in thickness. The abundance of the ore is its great feature. Forming the uppermost band on nearly all these large islands, where the dip is so low and the underlying strata confined to the cliffs along their eastern sides, the iron-stone beds are spread over the greater part of their areas, which in the aggregate amount to many thousands of acres. The islands being destitute of timber and the rocks much shattered by the surface water and the frost, the ore ready broken may be gathered up in inexhaustible quantities. The islands offer good shelter for vessels and the ore might be conveniently loaded in many places.[19]

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[18] Report of Geological Survey, 1875-6. p. 321.

Gypsum.

Banks of gypsum from ten to twenty feet high occur on both sides of the main Moose river between 31 and 88 miles above Moose Factory. The bank on the southeast side runs for about two miles; that on the opposite side about half that distance. The upper portion of the bed is mixed with marl, but ten feet in thickness at the bottom consists of solid gypsum. It is the ordinary hydrous saccharoidal variety, and mostly of a light bluish-gray color, a small proportion being pure white. The bed could be easily and inexpensively worked, and the gypsum utilized if wanted for fertilizing and other purposes, for which an article of a pure white color is not required. Dr. Bell remarks that the geological age of these deposits cannot be far from the Onondagan formation, and it would not be surprising if salt should also be found in the rocks with which they are associated.

Kaolin.

Kaolin or China clay suitable for the manufacture of porcelain is not known to occur in older Ontario, but in his report for 1880, Mr. Borron describes a large deposit on the Missinaibi branch of the Moose, about five miles below its junction with Coal Brook. It forms part of an immense bank or mound of beautiful white sand which extends along the river for at least a mile and rises to a height of not less than one hundred feet. An examination by Mr. Hoffman of the Geological Survey showed that the material formed with water a plastic mass, burned white, and might be said to be infusible. It is well adapted for the manufacture of all kinds of refractory ware, *i.e.*, fire brick, lining for grates, crucibles, scorifiers and the like. If employed for fine ware it would require to undergo preliminary treatment to free it from the numerous fine scales of mica which it contains. The sand forming the bulk of the bank is composed of pure translucent grains of quartz, with an occasional fragment of undecomposed felspar, and in the judgment of Mr. Borron, who has had some experience in glass-making, is greatly superior for this purpose to any obtained in either England or Scotland. The whole deposit is evidently due to the decomposition of granite, and doubtless owes its present position to the agency of ice and water.

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[19] Report of the Second Hudson Bay Expedition, 1885, p. 60.

Ochre, pyrites and natural gas.

Brown and yellow ochres are found on the Mattagami river between Grand Rapid and Long Portage. Iron pyrites also occurs on this river, as well as copper pyrites, the latter at a point about 25 miles below Kenogamisee lake. The bituminous Devonian limestones of the Abbittibbi river not far south of James bay contain indications of petroleum. Natural gas is continually rising to the surface in considerable volume at a place called Bubbling Water on the Missinaibi, a few miles above the junction of the Opazatika. Whether its presence is due to lignite in the bed of the river has not been determined. The immense banks of clay exposed on the rivers of this region may in many places be found suited to the manufacture of brick, and perhaps other articles of a like nature, should the march of events ever give rise to a demand for them in this hitherto untenanted country.

The foregoing enumeration of the known mineral deposits, limited as it is almost wholly to the river valleys where alone has any exploration taken place, gives good ground for the belief that when the extension of population and transportation facilities to this region confer a value upon its minerals, they will be found in quantity and richness sufficient to form the basis of a large and important industry.

ONTARIO'S SEA-SIDE.

On the shore of James bay.

The fact that the northern boundary of Ontario is composed of 200 miles of the shore line of James bay makes it possible for this province to claim rank as a maritime power. In order to obtain the advantage of her situation, the possession of a good seaport is a prime requisite. Unfortunately all accounts go to show that there are no good harbors on that part of the shore line which falls to the province's share. The mouth of the Moose river, which would be the most natural and convenient site for such a port, is extremely shallow and possessed of a very poor approach from James bay, in addition to which the bay itself for a long way out from the shore is of very inconsiderable depth The Hudson's Bay Company's boat, which is usually only a bark of a few hundred tons register, is obliged to cast anchor in the bay six miles from the mouth of the river, on the seaward side of a bar one mile in width. There is a channel on the bar about four hundred yards wide and not more than fourteen feet deep, through which at the rise of the tide the vessel may float in and anchor at "Ship Hole," where there is about eighteen feet of water, eight miles below Moose Factory. This post, which is one of the oldest of the Hudson's Bay Company's trading places, having

The harbor at Moose river,

been first established in 1675, is situated on Moose island, one of a group occupying a considerable portion of the river's bed for some miles up. Above, between and below these islands are numerous sandy shoals, those near the mouth of the river being laid bare at low tide. The channel is closely buoyed all the way, and on the departure of the boat for England the buoys are at once taken up by the Company's officers to prevent their being frozen in. It is necessary also on the approach of winter to haul up on the banks of the river all the sailing craft employed at the post, even to schooners of ninety or a hundred tons burden, to prevent damage or destruction when the ice breaks up in the spring.

The work of dredging the harbor at the mouth of the Moose river with the object of providing accommodation for sea-going craft would be a task of very great magnitude, probably far transcending the benefit to be derived from it. This extraordinary shallowness of the Moose at its mouth and for miles up stream has given rise to the opinion on the part of some that the river does not carry down to James bay the whole volume of water which it receives in its course, but that some portions of it are lost in the muskegs which it traverses in its lower reaches.[20]

and the possibility of its improvement.

On the possibility of utilizing the harbor at Moose river for purposes of navigation, Mr. A. P. Low of the Dominion Geological Survey makes the following remarks:

"The eight miles from the Ship Hole to Moose Factory is in places very shoal and is rapidly filling in its upper part so that the Company's schooner, drawing eight feet of water, can only come within about two miles of the Factory, whereas a few years ago her cargo was discharged close alongside that place. If a railway should be built to this harbor its terminus will need to be at Ship Hole; and to reach it a long and expensive line of embankment will have to be built from the south shore, across sand and mud flats, partly bare at low water, and owing to its exposed position it would need to be correspondingly strong to withstand the force of water during the late fall gales. If approached from the north side a large bridge will be required to cross the channel to the "Ship Sands," a low, flat, muddy island, partly covered with water at high tide, and lying close to the Ship Hole; in either case the terminus will have to be built largely on made ground. As the present anchorage, six miles without the bar, is in only thirty-six feet, and as the water gradually shoals towards the river's mouth to a depth of fourteen feet at high water on the bar, and is only eighteen feet at low water at the Ship Hole, with a less depth of water for the four miles between it and the bar, it will be seen that to fit this harbor for the entrance of moderate-sized steamers, with a draft up to twenty feet, extensive dredging operations will be necessary for almost the entire distance from the outer anchorage to Ship Hole."

Similar conditions at Albany.

The mouth of the Albany is no improvement on that of the Moose. Indeed in the opinion of Mr. Low the natural conditions there are even worse.

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[20] Such is the opinion of Dr. Newnham, Bishop of Moosonee, who says the waters of the largest rivers are so shallow in summer as to make canoeing difficult.

[21] Geological Survey Report, 1887-88, pp. 21-22 J.

He says: "Off the mouth of the Albany, for fifteen or twenty miles, the bottom is very flat and the deepest water not over twenty-five feet, slowly shoaling to twelve feet at the mouth, with numerous obstructive shoals and bars, the whole rendering it impossible for deep draft vessels to use it. The country around the mouth of the river is so low and swampy that it is hard to say where the land ends and the sea begins, and is totally unfit for the purpose of a railway terminus."[22]

Hannah bay.

The inlet named Hannah bay, which lies contiguous to Ontario territory, and receives the waters of the Harricanaw river, does not seem to offer an exception to the extraordinary shallowness which is so characteristic of the southern and western shores of James bay, and holds out no hope of affording any harbor accommodation. This is Mr. Low's description of it: "Hannah bay is so shallow that, with the exception of the river channels, it is almost completely dry at low water, and when a canoe is left by the tide the sensation experienced by its crew is anything but pleasant, as they have to debark and stand in the mud, often beyond sight of the low fringe of bushes on the high water line, awaiting the return of the water."

The waters of James bay itself are of very inconsiderable depth, and to this fact is doubtless due the shallowness of the harbors at the mouths of the rivers flowing into it. The sediment which these streams carry down to the coast being too heavy for their currents to bear out into deep water, it is being constantly deposited at their mouths and is filling up even those portions of their beds which lie immediately above. The following description by Dr. Bell will show the general character of James bay:

Dr. Bell's description of James bay.

"The southern and western shores of the bay are very low and level, and the bay itself is remarkably shallow, with the exception of a channel down its centre. For long distances we found it only possible to land from a small boat at high tide. Between high tide mark and the woods there is generally a broad, open, or marshy belt, interspersed with clumps of willow bushes and divided by muddy creeks. In some places this open border is raised above all but the highest spring tides, and constitutes a level prairie, supporting a rich growth of grasses and sedges. The marshy outline of the shore of the bay is often interrupted by points and peninsula-like islands, composed of boulders piled together in thousands, with scarcely any finer material amongst them. Owing to the numerous large rivers flowing into the southern portion of James bay, the water of this part is only brackish, and indeed in many places it is sufficiently fresh for drinking, and in some instances no taste of salt can be perceived for miles, even at a considerable distance from land. It is so shallow that a person may frequently touch the bottom with an oar, when almost out of sight of the low shore in a small boat. The constant currents kept up by the ebbing and flowing of the tides over this shallow, muddy bottom, render the water too turbid for fish to live in this part of the bay, although they are said to exist in the clearer water further out."[23]

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[22] Geological Survey Report, 1887-88, p. 22 J.

[23] Geological Survey Report, 1875-6, pp. 322-3.

NAVIGATION OF HUDSON BAY AND STRAITS.

Difficulties of navigation on Hudson bay.

The question of the navigation of Hudson bay is one which has been much discussed. While in the first instance it touches more closely the interests of Manitoba and the Northwest Territories, to whose products it would if practicable afford a short cut to the markets of England, it is also in some degree of importance to Ontario, in view of the fact that so large a portion of her territory is on the Hudson bay slope, and would be served by the route were it open to commerce. That some sort of navigation is practicable in Hudson bay admits of no doubt, as the vessels of the Hudson's Bay Company make their voyages from and to England unfailingly every year, bringing goods for the use of their employés and for trade with the Indians, and taking in return valuable cargoes of furs. The point in dispute is simply the period of each year during which such navigation can take place. The key to the situation is the navigability of Hudson Straits, which connect the bay with the Atlantic ocean. The surface of the bay itself is believed to be comparatively free from ice during the greater part of the year, and were there no other obstacles to contend with than the floating ice of the bay and the shore ice hemming in the ports, it is not unlikely that for at least half the year vessels could come and go with comparative immunity. The careful explorations and investigations of Lieut. Gordon, who, under instructions of the Dominion Government and accompanied by a staff of observers, made a voyage in 1884 in the Neptune and one each in 1885 and 1886 in the Alert for the express purpose of determining the period during which navigation was possible, appear to leave small room for doubt that this term in ordinary years is short, and indeed limited to about three months. In his report of 1886 that officer sums up the case in the following terms :

Testimony of Lieut. Gordon.

"Having now made voyages on three years to Hudson straits, and having carefully examined the reports by the observers as to the formation and movements of the ice in Hudson straits, I have the honor to submit the following statement in regard to the navigation of these waters. In discussing this question I think it well to state that I am not required to report on the commercial aspect of the case and whether Hudson straits navigation can be made to pay, nor do I, in the seasonal limits given, mean to state that it is impossible for a ship occasionally to get in earlier or leave later ; but, having carefully considered the subject, I give the following as the season during which navigation may in ordinary years be regarded as practicable for the purposes of commerce ; not, indeed, to the cheaply built freight steamer, commonly known as the 'ocean tramp,' but to vessels of about 2,000 tons gross, fortified for meeting the ice, and of such construction as to enable them to be fair freight carriers. These vessels must be well strengthened forward, should have wooden sheating and be very full under the counter ; the propeller should be of small diameter and well down in the water. I place the limit of size at about 2,000 tons, because a larger ship would be somewhat unwieldy, could not make such good way through the loose ice, and being unable to turn so sharply she would get many a blow that the smaller ship would escape. I consider that the season for the opening of navigation to such vessels as the above will on the average fall between 1st and 10th July. The position and movements of the ice I have already discussed, and need not here repeat. The closing of the season would be about the first week in October, partly on account of the descent of old ice from Fox channel into the western end of the straits, this old ice being rapidly cemented into solid floe by the formation of young ice between the pans; in such ice no ship, however powerful, could do anything to free herself. At this time, too, the days are rapidly shortening, and snowstorms are frequent, though not of great duration."[24]

The projected Hudson Bay Railway and its prospects.

Port Nelson and Port Churchill.

The point at once suggests itself whether a route which is open for only three months of the year, and then only to specially built and equipped vessels, is likely to be of much practical utility to either Manitoba and the Northwest or to Ontario. The difficulty of carrying on a profitable trade under such onerous conditions would be very great. For instance, it would hardly be possible to move to the seaboard and transport to the English market the crops of any one harvest during the same year. This would necessitate the storing of them in elevators at the port on Hudson bay or where they were grown for at least nine months, at large expense, and with the consequent loss of interest and risk of losing a favorable market. It may be doubted whether the loss and delay to which traffic would be exposed would not bring freight charges up to at least the level of those of the more southern and longer routes. It is no doubt possible to build a railway from a point in Manitoba or the Northwest without unusual difficulty, but if the line which is at present projected is to have its terminus at the mouth of the Nelson river, the promoters will probably find that when they have reached the seaboard they have not reached a port. The same shallowness of water as exists at the mouth of the Moose characterizes the estuary of the Nelson. This river, which in point of volume may be ranked among the great rivers of the world, is very muddy, and has deposited an immense quantity of sediment at its mouth, which in consequence affords very indifferent accommodation for shipping. In Lieut. Gordon's opinion it is one of the most dangerous places in the world for ships, and besides the very large amount of dredging which would have to be done to make a channel and basin capable of holding freight-carrying vessels, there are 27 miles of channel which would require to be closely buoyed, and in addition a light-ship would be necessary for the guidance of mariners in bad weather.

There are no harbors on the south or west coast of the bay, except those formed by the mouths of the rivers, and the only other available port would be at Fort Churchill, where the river of that name falls into the bay a considerable distance north of the Nelson. The harbor here is naturally a good one, there being a spacious deep water basin large enough to accommodate a business of great magnitude, and a good mud bottom which affords an excellent holding ground, notwithstanding the rapid tides. The northerly position of Fort Churchill would however add considerably to the length of the railway, and consequently to the expense of working it. The selection of a seaport terminus on Hudson bay for a problematical railway does not appear to be a pressing matter, but if ever a line from the west reaches tidewater on the bay it would doubtless be found that Fort Churchill has essential advantages over any other place that can be named.

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[24] Report of the Hudson Bay Expedition of 1886, pp. 90-91.

FISHERIES AND FURS.

Fisheries in James and Hudson bays.

Owing to the muddy and shallow character of the water in a large portion of James bay, the fisheries there are not extensive. The lakes and rivers tributary to it from the south contain almost all the principal food fishes, such as the salmon and whitefish, salmon trout, herring, pike, etc., which provide a large proportion of the sustenance of the natives. Little has yet been done to show the extent to which fish of commercial value are to be found in Hudson bay, though both Indians and Eskimo find varieties there suitable for their own use. The fishes exported from Hudson bay and straits are salmon and salmon trout, but the codfish does not appear to go farther west than the eastern side of Ungava bay. The mouths of several rivers falling into Hudson straits are resorted to in large numbers by salmon of fine quality, in catching and exporting which a considerable business is done by the Hudson's Bay Company. For many years vessels from New England and Dundee have carried on the pursuit of whales in Hudson straits and bay. There are several varieties which are sought after, the most valuable being the one known as the "right whale," (*balaena mysticetus*), single individuals of which are worth as much as $18,000. Their value is due to the large amount of whalebone they yield, which brings a high price. The right whale is becoming very scarce, and fears are expressed lest the excessive rigor with which it has been hunted should end in exterminating it altogether. The whale most characteristic of Hudson bay is the white whale (*beluga catodon*), great numbers of which are annually taken for the sake of the oil which they produce. Seals of several kinds are found, some of them being very large in size, and all of greater or less value, but the fur seal of the Pacific ocean, the most highly-prized of the species, is absent. Other fish and mammals which possess a commercial value are the narwhal or unicorn, the porpoise, the walrus and the polar bear.

The fur trade.

Furs are a very important product of the Hinterland, and form the principal item of export from the territory north of the height of land. The principal fur-bearing animals are the beaver, mink, marten, otter, fisher, lynx, fox, bear etc. The trapping of these creatures is done almost entirely by the Indians, who barter the spoils of their chase with the Hudson's Bay Company for clothing, food, ammunition, and other necessaries of life. Though scarcely ranking as a fur-bearing animal, the rabbit is important to the native population from its edibility and plentifulness. The caribou ranges as far south as the north shore of lake Superior, but does not occur on the swampy plains of the north, while the moose is found in considerable numbers north of lakes Huron and Nipissing and also in the neighborhood of Lake of the Woods. The height of land region and country to the south wherever settlement has not penetrated are plentifully stocked with animal life, but in the peat swamps of the northern plain the fur-bearing animals are comparatively scarce, and their rarity often inflicts severe hardships upon the natives, of whose winter food supply they constitute no small share. A single cargo of furs sent by the Hudson's Bay Company to England is sometimes worth as high as $500,000. Wild fowl, such as ducks and geese, find in these northern solitudes their favorite feeding and breeding grounds, the ponds and lakes which occur among the bogs affording them shelter inaccessible to even the Indian hunter.

POPULATION OF THE HUDSON BAY SLOPE.

Population north of the height of land.

The territory north of the height of land is peopled mainly by Indians and half-breeds, the white population being confined almost exclusively to the officers and servants of the Hudson's Bay Company. The census returns for 1891 give the population of the unorganized territory of Algoma district as 1,200, and of that of Nipissing as 910; in all 2,100; while in 1879 Mr. Borron estimated the number of inhabitants at 2,000 or 2,500, both native and European. Since that time the only appreciable increase has been due to the small settlements which have clustered round the stations of the Canadian Pacific Railway on that part of the line situated north of the divide. The Indians on and near the coast of James bay belong to the Swampy Cree tribe, and speak a dialect of the Cree language, while those living farther south are Ojibways. In the winter the Indians are scattered over the immense territory hunting and trapping, and on the approach of spring they repair to the Hudson's Bay Company posts to exchange their season's catch of furs for goods of various kinds. They usually remain in the neighborhood of the posts most of the summer, the women and children fishing, and the men either hunting or engaged in making hay, voyaging or other service for the Company. Most of the natives have European blood in their veins, the Company's officers and servants very frequently taking to themselves Indian wives. The half-breed population is consequently almost wholly of Scotch, English or Scandinavian extraction, there being very few French half-breeds in the territory. Both natives and half-breeds are spoken of in terms of praise by those familiar with them, the influence of the Hudson's Bay Company officials having on the whole had an educative and beneficial effect upon the Indian character. They are industrious, honest, peaceable and intelligent. Their mode of life is a hard one, the scarcity of game in some seasons reducing them to threatened and sometimes to actual starvation. The Indian title has not yet been wholly extinguished in this region, no treaties having been made to acquire the aboriginal rights. As a consequence the reserve system does not prevail, and the Indians are free to roam about as they may wish.

Government by the Hudson's Bay Company.

So far the whole work of governing the region north of the height of land has been practically in the hands of the Hudson's Bay Company. Neither the Provincial nor the Dominion Government provides schools, administers justice, or carries the mails. What means of education exist are due to disinterested philanthropy, chiefly that of the Church Missionary Society of London, England.[25] Otherwise the most elementary functions of government are discharged by the Hudson's Bay Company, whose rule has on the whole been a beneficent one. On a small scale the Company has for many years played a part similar to that enacted by the East India Company down to 1858, but with the advantage of dealing only with white men wholly dependent and with natives almost wholly dependent upon the Company for supplies and support. Its policy has been here as in other parts of the continent to refrain from interfering in quarrels among the natives, and while carefully guarding the interests of the Company and making as large a profit as possible out of its trade, to deal justly and equably with all. The limited commerce of the territory, which is wholly with England, is altogether in the hands of the Company, and this fact is of itself almost sufficient to confer upon it the commanding influence which it enjoys.

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[25] A small grant ($100) is now made annually by the Education Department, Toronto, to the Bishop of Moosonee, in aid of the school at Moose Factory.

Drawbacks of life at James bay.

The few whites of this northern region lead a life of of isolation and exile, and have very few points of interest in common with the other inhabitants of the province. There are only three mails a year to Moose Factory, and the inhabitants of that distant post and adjacent territory are chronically three or four months behind the times so far as the outside world is concerned. The chief connecting link between them and the Dominion is the custom house officer, who levies toll on the goods imported from England at exactly the same rates as are collected at Montreal or Toronto. For the year ending 30th June, 1892, there was collected at Moose Factory the sum of $14,551.01; for the year ending 30th June, 1893, $10,567.01, and for the year ending 30th June, 1894, 9,150.70, a total in three years of $34,268.72. The average yearly collection is $11,422.90, the immediate effect of which of course is to add the amount of duty to the selling price of the articles imported, and thus to increase by a considerable percentage the cost of living not only of the Hudson's Bay Company's servants, but also of the native population, who can ill afford to bear the burden. The spiritual welfare of the people, both Indian and white, is looked after by the Church of England and the Roman Catholic Church, principally the former, to which many of the Indians belong. The bishop of Moosonee, Rev. Dr. Newnham, has his official seat at Moose Factory, and his diocese extends inland on all sides of Hudson Bay covering an area of about 600,000 square miles.

FUTURE OF THE HINTERLAND.

Prospects of northern Ontario.

To foretell the future of the great Hinterland of Ontario is an impossible task. Any prophecy would doubtless be discredited by the issue of events. It is easy to underestimate the part which it is destined to play in the history of our province, and it is also possible to overrate it. We might entertain too gloomy a view if we allowed our minds to dwell upon the countless rocky ridges and great stretches of peat morass which it undeniably contains; and on the other hand our imagination might take fire too readily if we contemplated exclusively its vast extent, its fertile belts, and its wealth of minerals and timber. Settlement is beginning to take place on a considerable scale in some of the areas of good land, which will undoubtedly become the homes of a large agricultural population, while great tracts will wait long before the covetous eyes of land-seekers will find in them much attraction. But the time will doubtless come when the pressure of population on the means of subsistence will force all available land into cultivation; and when that period arrives there is no reason why the now neglected areas of northern Ontario should not sustain a hardy people like the Swedes and Norwegians, or other north Europeans, in comfort and plenty. Railway communication between the cultivable districts and older Ontario is the first step in the development of the Hinterland. Railways have been projected into the fertile areas of both the west and the east. The Ontario and Rainy River railway will, when completed, run from some point on the Port Arthur, Duluth and Western railway to the rich agricultural belt extending from Rainy lake to Lake of the Woods, and is intended eventually to reach the latter place. The Nipissing and James Bay railway which is to start at North Bay and terminate at James Bay will in its southerly portion run through a district containing a very large quantity of pine timber, and when it strikes the shore of lake Temiscaming will afford access to the great tract of fine soil which lies to the west and north of that lake. It seems likely that this district will be one of the first to be opened up and settled, and a railway into it from older Ontario would secure to the province the advantage of the trade which would doubtless be developed there upon its dormant resources falling into the hands of energy and enterprise.

A field for expansion.

It is satisfactory to know that Ontario has room for expansion within her own borders, and that her sons do not require to leave their native province to find as good an opportunity for acquiring a competence as is offered anywhere else to industry and thrift. It is coming to be known that in northern and northwestern Ontario the soil is as fertile, the climate as good, and the general conditions as favorable, as in either the provinces of the Northwest or any of the states of the Union. Railway communication, which in some of the fertile areas is wanting, bids fair to be supplied. The Ontario farmer or farmer's son who wishes to better his lot will find in Ontario the schools, the churches, the municipal and parliamentary institutions, the society, the respect for law and order, in a word all the conditions to which he has been accustomed, and it is therefore possible to begin life in a new district without experiencing a violent break in either habits or surroundings. All of these conditions may not be present at the start, but the increase of settlement will bring about their development and steady growth.

Stages of growth in a community.

The capacity for self-government which characterizes the English-speaking race is nowhere more noticeable than in Ontario, and nowhere have public institutions been moulded so as to give that capacity more perfect freedom of action. The township is the unit of municipal government, and it is interesting to watch the evolution of a township from a mere geographical expression to an active member of the public community, fully equipped for the direction of those matters of local moment so important to its inhabitants in the earlier as well as in the later stages of its history. First, the Department of Crown Lands surveys off into farm lots of 100, 200 or 320 acres each a block of wild land, and sooner or later opens it for settlement. If the soil is fertile and the locality inviting, it will probably be found that hardy bushmen of the pioneer class have anticipated the action of the Department, and have "squatted" upon lands which took their fancy without waiting for the forma-

Municipal and

lity of their being placed upon the market. Settlers find their way in, are suited with the land, write their friends to come and join them, and so the population slowly increases. Roads are as essential to the growth of the small community as arteries are to the human body, and in the early stages of its career the Department of Crown Lands comes to its aid with grants to build needed lines of communication, to the construction of which the settlers themselves frequently contribute. There is provision in the law by which even in this inchoate state of the community formal steps may be taken to levy upon all landholders an equal rate towards the expenses of building these roads. The next step is organization, by which the full status of a self-governing township, with reeve and council, is attained. Usually, this dignity is assumed in conjunction with one or more neighboring townships, which thus share the necessary expense of incorporation and administration, the partnership being maintained until each member of it is able to stand alone. The council annually elected by the people has full control of roads, bridges and the many smaller matters which enter into the corporate life of the community, and is endowed with extensive powers of taxation to carry its determinations into effect.

educational institutions.

Concurrently with the development of the municipality goes on the growth of educational institutions. Even before the township is organized, school sections may be set apart on petition of the heads of five families resident therein. The township council is charged with the duty of dividing the township into sections for school purposes, but these sections when formed are practically autonomous in the administration of their affairs, subject of course to the general educational law of the province. The ratepayers therein elect a board of trustees who build the schoolhouse, engage the teacher, and determine the amount to be levied by the township council on the ratepayers of their section for school purposes.

It is thus seen that the settlers in the new districts of the province are in possession of nearly the same powers and privileges as regards the important matters of municipal government and education, so far as the circumstances will admit, as the people of the older counties are. Nor are they deprived of a voice in the election of members of the local and federal parliaments. On the contrary, elaborate precautions are taken and considerable expense incurred to give them that share in the free choice of a representative which is the birthright of every citizen.

The settlement of Ontario has so far been very largely a spontaneous process, and has been carried on without many of those attempts at wholesale colonization which have been tried in other provinces and countries, often with very doubtful results. The merits of the country, and not undue puffing or injudicious praise, have attracted a class of settlers who with their descendants form the backbone of the community, and it is to a continuation of the process which has been so successful in the past that we may look for the occupation and peopling of the Hinterland. Growth so made may be slow, but it will be healthy and enduring, and there will be no discontented settlers, misled by false hopes and disappointed because the reality has fallen short of their expectations, to belittle the country and invoke wrath upon the heads of those who deceived them. With the advantages of fertile soil, good markets, abundant timber, temperate climate and free institutions, it would seem that the northern regions of Ontario must at no distant date attract a much greater share of attention than they have hitherto done. Looking into the future one may descry the soil, the timber, the minerals and the fisheries of this great wild land affording the means of livelihood to a hardy race whose frames will be as robust, and whose love of liberty will be as great, as those of a nation nurtured in a northern clime are wont to be.

T. W. G.

SECTION IV.

CALCIUM CARBIDE AND ACETYLENE GAS.

Natural sources of supply for fuel and light.

A subject of large and ever-growing interest to the people of Ontario is the supply of materials for fuel and light. For fuel we have been dependent upon the wood of our forests, and for light on the fat of animals or the gas and oil of our rocks. There is no other natural source provided in the country itself, and as the timber area diminishes with the process of settlement we are being forced to look elsewhere for the materials of supply. Coal furnishes us with both fuel and light, and almost all that we consume comes to us from the mines of Pennsylvania and Ohio. Petroleum oil is also imported from the same states to some extent; but with the high protective duties the home producers are enabled to control the market almost wholly, in spite of the limited production of the Ontario oil fields.

Importations of petroleum and coal.

Twenty-five years ago, in the fiscal year 1868-9, the import of crude petroleum and its products into Ontario was 47,054 gallons, valued at $12,053, upon which the charge for customs duty was $6,214. In 1893-4 the total import of crude and refined oils into the province was 2,388,402 gallons, valued at $132,159, and the duty levied was $169,812. In the former year the average rate of duty was 13 cents per gallon specific or 51½ per cent. ad valorem, and in the latter year 7 cents specific or 128 per cent. ad valorem; yet the average value per gallon, calculated on the entry valuation plus the duty, fell from 39 cents in 1868-9 to 12½ cents in 1893-4. Oil for light, as these figures show, is not a very important item in the foreign trade of the province; we would hardly miss it if excluded altogether, except perhaps for the higher price which monopoly might enable the home producers to fix and maintain. It is otherwise however with coal, which we cannot produce at home for the sufficient reason that long before the carboniferous age of the earth, as well as during and after that age, our province was dry land, so that the coal measures are wholly wanting; or, if formed, that they were subsequently broken up and swept away by the action of denuding agencies. The coal fields of Nova Scotia, of the Northwest Territories and of British Columbia might supply us if Nature had not interposed the barrier of distance; and so, notwithstanding barriers of governmental invention, we obtain what is demanded by our necessities from Ohio and Pennsylvania. In 1868-9 the total quantity brought into Ontario for consumption was 212,305 tons of coal and coke, valued at $680,897. Twenty-five years later, in 1893-4, the quantity was 2,441,800 tons, valued at $7,500,558, but to which should be added $798,322 paid for customs duty, making the total $8,298,880. This includes coal, coke and dust of the hard and soft varieties. Now it must be borne in mind that very little of this article of fuel is used in the rural districts, where wood is still more or less abundant. It is all or nearly all consumed in the cities, towns and

Comparative per capita consumption of coal in the province.

villages of the province, excepting what is required by the railways and steamboats; and therefore in computing averages per capita of population the inhabitants of the rural districts are properly excluded. In 1868-9 the average of the province was only two-thirds of one ton per capita, valued at $2.25. In 1893-4 it was 2⅔ tons per capita, valued at $9.15.[1] These facts illustrate the changed conditions of our country in the short period of twenty-five years, due to the cutting off of our natural supplies of fuel, and they fully justify the interest which this Bureau has taken from the first in the question of fuel supply; there is no other of greater moment before us in Ontario, as regards the economies, the comforts and the very existence of our people. It is not merely that we should aim to be independent of foreign states for the necessaries of life, of which in our climate fuel and light are among the chief, but also that the necessaries should be provided cheaply and in abundance.

A process for converting lime and carbon into material for light and fuel.

The most promising discovery in recent years for the supply of light and fuel has come into prominence in the scientific world during the last few months, viz., a process for the economic production of calcium carbide and acetylene gas. It is the invention, too, of a young Canadian, and if only the half of the expectations concerning it are realized we shall be far on the way to a satisfactory solution of the fuel and light problems. The papers which follow give interesting accounts of the discovery, as well as of its uses; and although it is likely that further investigations and experiments will add to the value of the invention, there does not appear at present to be substantial reason for doubting that it can be practically and successfully applied to serve in a large degree the purposes for which it is intended.

Willson's claim of discovery.

It is not pretended by the inventor, Thomas Leopold Willson,[2] that he discovered acetylene gas, or the properties of the carbides. His claim is that he has found a process for the commercial production of calcium carbide, using for materials common lime and carbon in any form—hard or soft coal, coal dust, charcoal, petroleum, tar or peat—and treating them in an electric furnace; and he is confident that where electricity can be generated with water power the cost of manufacturing calcium carbide brings it easily into competition with other materials of fuel and light. A plant erected near a great water power like Niagara Falls, Mr. Willson maintains, may supply the continent at a figure with which coal gas cannot compete; for there the power is ample for almost any conceivable requirement, alongside a mountain of limestone, while coal dust or culm may be had for little more than the cost of haulage from the mines of Pennsylvania and Ohio.

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[1] In computing these estimates the urban population of the province is taken at 335,745 in 1868-9, and at 906,262 in 1893-4.

[2] Thomas Leopold Willson was born at or near the village of Princeton, in the county of Oxford, in 1860. His father, the late Thomas Whitehead Willson, was a son of Hon. John Willson, a gentleman who figured conspicuously in the Legislature of Upper Canada in the early part of the century. In the Documentary History of Upper Canada (vol. I., p. 101) Dr. Hodgins says: "Mr. John Willson was elected to represent the west riding of the county of York [Halton] in 1809 and 1813, and the county of Wentworth in 1820, 1825, 1829 and 1831. He became Speaker of the House of Assembly in 1825." In the Legislature he took a leading part, according to Dr. Hodgins, in carrying through a measure for establishing the public school system of the province in 1816 (pp. 94-100), but his name is not mentioned in connection with the Act of 1824 for the permanency and extension of the previous Acts (p. 197). The Hamilton Spectator of May 29, 1860, says the Act of 1816 was drafted by Mr. Willson and passed into law mainly through his influence, and that he afterwards, "when it was about to expire in 1824, introduced and carried an Act to make it perpetual." "Thus," the Spectator says, "was laid the foundation of that admirable system of education which has since the union of the provinces placed the inestimable blessing of a generous share of education within the power of every person brought up in the province." This Hon. John Willson was born in New Jersey in the year of American Independence, he came with his guardian to live at Niagara the year before Upper Canada was established as a province, and settled upon a farm on the shore of lake Ontario, in Saltfleet, Wentworth county, in 1797, where he lived until his death in 1860. The grandson is proving himself worthy of the stock of this pioneer, and of the school system which he did so much to organize and establish. From 1872 to 1881 (as I learn from Mr. C. A. Abraham of the Woodstock Sentinel Review) he resided in Hamilton and was trained in the excellent schools of that city. From an early age he showed a marked fondness for chemical and electrical experiments, and at nineteen he produced the first electric light exhibited in the city, with the help of Senator Sanford and Mr. Hood of the Royal Hotel as business partners. But feeling the necessity of securing a wider field for his work, he went in 1881 to New York, and there unaided by anything but his personal ability, determination and integrity he has won success and fame.

The attention of capitalists has already been drawn to the new discovery. A leading manufacturer of Leeds, Eng., has been negotiating for the right to use the patent in that country, and three distinguished scientists have been employed by him to enquire into and report upon the merits of the invention. One of these is Professor Lewes, whose report is substantially the paper read before the Society of Arts. In the United States a plant for the production of calcium carbide is expected to be ready for operation shortly, and arrangements are being made to procure electrical energy on both sides of the Niagara river, from the strong company which controls the power franchises at the Falls. The Canadian General Electric Company has acquired the patent for Canada, and a plant is now in course of construction at their shops in Peterborough. As prudent men, the directors of the company will begin upon a moderate scale, and if it is shown that calcium carbide can be produced economically and that there is reasonable assurance of a market being found for it in the country, they will no doubt prepare to meet the demand as fast as it grows.

Steps taken to utilize the invention in Great Britain,

the United States

and Canada.

Like every other invention, the value of Mr. Willson's process is variously estimated. In the opinion of some authorities the cost bars it from competing with any hope of success with other and better known processes for manufacturing materials of fuel and light, not to speak of the bad odor of acetylene and its dangerous explosive qualities. In the opinion of others the question of cost has already been decided satisfactorily. And as for the bad odor of the gas, they say that this is one of its good qualities, since it facilitates the discovery of a leak; in burning, it gives off no odor, all or almost all of the gas being consumed in the flame, which is not the case with coal or water gas. And as regards the risk of explosion, they say that this is a matter of proper management. There seems to be no doubt however that the utility of acetylene as an enricher of common gas, which was a merit at first claimed for it, has no substantial value, because other methods are found to give cheaper and equally good results.

Various estimates of the value of the invention;

The papers which follow present the subject fully enough for a fair understanding of it, and most of the criticisms appear to have been met as completely as the criticisms of any new discovery can be met until demonstration comes in the "furnace test." Bessemer was ignored and ridiculed in a more humiliating way by eminent men than Willson has been; and if that instance has any value now, it is that we should wait patiently for the demonstration.

but demonstration will come with the furnace test.

THE COMMERCIAL SYNTHESIS OF ILLUMINATING HYDRO-CARBONS.[3]

By Professor Vivian B. Lewes.

Analysis and synthesis.

The two methods most used in chemical science for tracing the changes taking place in matter, and determining the composition of bodies, are, firstly, the breaking up of compounds into their ultimate constituents, a process which is called 'analysis'; and, secondly, the building up of the compound from the elementary matter which forms it, a process to which the name of 'synthesis' has been given.

Elements of chalk.

If we take chalk and heat it in the limekiln, or in the chemist's crucible, a heavy, colorless gas called carbon dioxide escapes from it, and leaves behind a substance which we know as quicklime. If now this quicklime be further acted upon by chemical methods, it can be shown to contain the metal calcium and the elementary gas oxygen, whilst the carbon dioxide when collected can be decomposed into the elements carbon and oxygen, and by such a series of operations as this we might perform the analysis of chalk.

If now we start with the metal calcium, with carbon, and with oxygen, it is perfectly simple to reverse the operation, and rebuild the chalk molecules from these elementary forms of matter; by burning the carbon and calcium respectively in oxygen, we obtain the quicklime and the carbon dioxide, and by bringing these substances together in the presence of moisture, chalk or calcic carbonate is once more formed, and we have synthetically built up the chalk from its constituents.

Forming organic products from inorganic materials.

By such simple methods as these most inorganic compounds can be synthetically produced from elementary matter, but in the so-called organic chemistry it is not so easy to employ such constructive methods for the formation of compounds. Up to the end of the first quarter of this century it was supposed that organic bodies were only produced as the result of animal and vegetable life, and that their formation was due to the so-called 'vital force' which was credited with governing all changes taking place in living organisms.

In 1828 Wohler showed that urea could be formed from cyanate of ammonium, whilst later on Fownes made cyanogen by the direct combination of carbon and nitrogen, these two discoveries taken together proving the possibility of forming an organic product from inorganic materials; and after this point had been reached, and the possibility of applying synthetic methods to the production of organic bodies had been demonstrated, compound after compound was built up without the aid of either vegetable or animal life, and the barrier between inorganic and organic chemistry finally broken down. Cases however in which such methods could be commercially successful were few and far between, as in most cases the processes which had to be adopted were costly and laborious.

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[3] A paper read before the Society of Arts of London, England, January 16th, 1895, and printed in the Journal of the Society, January 18th.

ACETYLENE GAS.

The hydrocarbons

In all the phenomena of ordinary combustion which we employ to provide us with heat and light, there are no compounds of greater interest than the class of organic bodies which, being formed of carbon and hydrogen in various proportions, have been termed hydrocarbons, and it is to this class of bodies that all the gases which can be used as ordinary illuminants owe their luminosity. Amongst the hydrocarbons the simplest compound is acetylene, in which two atoms of carbon are united with two atoms of hydrogen; and it has long been known that, if a stream of hydrogen is passed through a globe in which the voltaic arc is produced between carbon points from a sufficiently powerful current, this gas is produced in minute quantities. It can also be formed in small quantities by the decomposition of carbon tetrachloride in the presence of hydrogen by the induction spark, whilst it is produced during processes of checked combustion in hydrocarbon flames.

and their derivatives.

The direct combination of carbon and hydrogen in the electric arc is a true case of synthesis, and if we could form acetylene in this way in sufficiently large quantities, it would be perfectly easy to build up from the acetylene the whole of the other hydrocarbons which can be used for illuminating purposes. For instance, if acetylene be passed through a tube heated to just visible redness, it is rapidly and readily converted into benzol; at a higher temperature naphthalene is produced, whilst by the action of nascent hydrogen on acetylene ethylene and ethane can be built up. From the benzol we readily derive aniline and the whole of that magnificent series of coloring matters which have gladdened the heart of the fair portion of the community during the past five and twenty years, whilst the ethylene produced from acetylene can be readily converted into ethyl alcohol by consecutively treating it with sulphuric acid and water, and from the alcohol again an enormous number of other organic substances can be produced. Thus acetylene can without exaggeration be looked upon as one of the great keystones ot the organic edifice, and, given a cheap and easy method of preparing it, it is hardly possible to foresee the results which will be ultimately produced.

From acetylene we can produce all those bodies which we are accustomed to look upon as the most important ones in our coal-gas, and which up to the present time have never been produced from anything but coal, hydrocarbon oils, or other organic matter undergoing destructive distillation; but it has often occurred to those of us who are interested in the manufacture of illuminating gas that as the supply of coal gets smaller, and as oil in time begins to share the same fate, some new sources for our illuminants and our fuels must be sought; and in my mind at any rate the synthetic production of hydrocarbons has long been a day dream, which I however never expected to see possible on a commercial scale.

Not only was the synthetic production of acetylene in the electric arc well known, but ever since water-gas has been introduced small traces of acetylene and methane have been found in it under conditions which render it impossible that they should have been produced from any compound present in the incandescent fuel. They must therefore have been due to the direct combination of carbon and hydrogen, but these traces only occurred in quantities so small as rarely to amount to one per cent., and it was manifest that the production of the compounds could not take place in large quantities under influences which would immediately tend to decompose them.

History of the discovery of economic production

In 1836 it was found that when making potassium, by distillation from potassic carbonate and carbon, small quantities of a bye-product consisting of a compound of potassium and carbon were produced, and that this was decomposed by water with liberation of acetylene; whilst Wohler by fusing an alloy of zinc and calcium with carbon made calcic carbide, and used it as a source from which to obtain acetylene by the action of water.

Nothing more was done until 1892, when Macquenne prepared barium carbide by heating at a high temperature a mixture of barium carbonate, powdered magnesium and charcoal, the resulting mass evolving acetylene when treated with water; whilst still later Travers made calcic carbide by heating together calcic chloride, carbon and sodium. None of these processes however gave any commercial promise, as the costly nature of the potassium, sodium, magnesium or zinc-calcium alloy, which had to be used, made the acetylene produced from the carbide too expensive.

It is now some 25 years ago since I listened to one of the Friday evening lectures at the Royal Institution, given by Mr. Greville Williams, and in the same way that the thread of some melody lingers in one's mind, so has the concluding sentence of that lecture constantly recurred with ever-increasing force: "The impossible is a horizon which recedes as we advance; and the terra incognita of to-day will to-morrow be boldly mapped upon every schoolboy's chart." The haunting dream of the possibility of synthesizing hydrocarbons commercially has, with the onward march of science, to-day become an accomplished fact.

As is so usual in the history of discovery, the factor which has endowed us with the power of doing this was not the outcome of an elaborate research, having this discovery for its ultimate goal, but was found by chance during the search for another object.

by Willson in the electric furnace.

Whilst working with an electric furnace, and endeavoring by its aid to form an alloy of calcium from some of its compounds, Mr. T. L. Willson noticed that a mixture containing lime and powdered anthracite, under the influence of the temperature of the arc, fused down to a heavy semi-metallic mass which having been examined and found not te be the substance sought was thrown into a bucket containing water, with the result that violent effervescence of the water marked the rapid evolution of a gas, the overwhelming odor of which enforced attention to its presence, and which on the application of a light burnt with a smoky but luminous flame.

A result of double decomposition.

Investigation into the cause of this phenomenon soon showed that in a properly constructed electric furnace, finely ground up chalk or lime, mixed with powdered carbon in any form, whether it were charcoal, anthracite, coke, coal or graphite, can be fused with the formation of the compound known as calcic carbide, containing 40 parts by weight of the element calcium, the basis of lime, and 24 parts by weight of carbon, and that on the addition to this of water a double decomposition takes place, the oxygen of the water combining with the calcium of the calcic carbide to form calcic oxide or lime, whilst the hydrogen unites with the carbon of the calcic carbide to form acetylene, the cost of the gas so produced bringing it not only within the range of commercial possibilities for use per se, but also the building up from it of a host of other compounds, whilst the production of the calcic carbide from chalk and from any form of carbon renders us practically independent of coal and oil, and places in our hands the prime factor by which Nature in all probability produces those great underground storehouses of liquid fuel upon which the world is so largely drawing to-day.

ECONOMIC EFFECT OF THE DISCOVERY.

Value of acetylene as an illuminant.

Wonderfully and intensely interesting as is the train of thought opened up by the discovery of this substance and its commercial production, the object I have in view this evening is not to discuss theoretic possibilities, but to show you the important effect which it will have in the direction of our great gas industry, and the phase of this which I wish to deal with specially is the value of acetylene, either for producing per se an enormously high illuminating effect, or for the enrichment of low grade coal-gas.[4]

Changes of decomposition.

When the calcic carbide is placed in a glass flask, and water allowed to slowly drip upon it from a dropping tube, the decomposition at once commences with considerable rapidity, and the acetylene pours off in a continuous stream; as the decomposition continues, the solid mass in the flask swells up, and is eventually converted into a mass of slaked lime.

Calcic carbide is a dark gray substance, having a specific gravity of 2.262, and when pure a pound of it will yield on decomposition 5.3 cubic feet of acetylene. Unless however it is quite fresh, or means have been taken to carefully protect it from air, the outer surface gets slightly acted upon by atmospheric moisture, so that in practice the yield would not exceed five cubic feet. The density and hardness of the mass however protect it to a great extent from atmospheric action, so that in lumps it does not deteriorate as fast as would be expected, but in the powdered condition it is rapidly acted upon.

For commercial purposes the carbide will be cast direct from the electric furnace into rods or cylindrical cartridges, which, when 12 inches long and 1¼ inches in diameter, will weigh one pound, and will give five cubic feet of gas.

The acetylene so made when analyzed by absortion with bromine, the analysis being also checked by determining the amount present by precipitation of silver acetylide, gives 98 per cent. of acetylene and 2 per cent. of air, and traces of sulphuretted hydrogen, the presence of this impurity being due to traces of sulphate of lime—gypsum—in the chalk used for making it, and to pyrites in the coal employed.

Safe properties of the gas.

Acetylene is a clear, colorless gas with an intensely penetrating odor which somewhat resembles garlic, its strong smell being a very great safeguard in its use, as the smallest leakage would be at once detected; indeed so pungent is this odor that it would be practically impossible to go into a room which contained any dangerous quantity of the gas.

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[4] Experiments on the enrichment value of the gas subsequently made by Professor Lewes have convinced him that "acetylene will be of no practical use to the gas manufacturer as an enrichment of gas in bulk, as it can never hope to compete in price with oil gas as made by the Peebles process."

This is an important point to remember, as the researches of Bistrow and Liebreich show that the gas is poisonous, combining with the hæmoglobin of the blood to form a compound similar to that produced by carbon monoxide, whilst the great danger of the latter gas is that having no smell its presence is not detected until symptoms of poisoning begin to show themselves, so that no fear need be apprehended of danger from this source with acetylene.

Its solubility,

Acetylene is soluble in water and most other liquids, and at ordinary temperature and pressure—60° Fahr. and 30 inches of mercury—10 volumes of water will absorb 11 volumes of the gas, but as soon as the gas is dissolved the water being saturated takes up no more. Water already saturated with coal-gas does not take up acetylene quite so readily, whilst the gas is practically insoluble in saturated brine—100 volumes of a saturated salt solution only dissolving 5 volumes of the gas. The gas is far more soluble in alcohol, which at normal temperature and pressure takes up six times its own volume of the acetylene, whilst 10 volumes of paraffin under the same conditions will absorb 26 volumes of the gas. It is a heavy gas, having a specific gravity of 0.91.

and burning qualities.

When a light is applied to acetylene it burns with a luminous and intensely smoky flame, and when a mixture of one volume of acetylene with one volume of air is ignited in a cylinder a dull red flame runs down the cylinder, leaving behind a mass of soot and throwing out a dense black smoke. When acetylene is mixed with 1.25 times its own volume of air the mixture begins to be slightly explosive, the explosive violence increasing until it reaches a maximum with about twelve times its volume of air, and gradually decreases in violence until with a mixture of one volume of acetylene to twenty of air it ceases to be explosive.

Behavior under pressure.

The gas can be condensed to a liquid by pressure, Ansell finding that it liquefied at a pressure of 21.5 atmospheres, at a temperature of 0° C., whilst Cailletet found that at 1° C. it required a pressure of 48 atmospheres, the first-named pressure being probably the correct one. The liquid so produced is mobile and highly refractive, and when sprayed into air the conversion of the liquid into the gaseous condition absorbs so much heat that some of the escaping liquid is converted into a snow-like solid, which catches fire on applying a light to it, and burns until the solid is all converted into gas and is consumed.

The cause of luminosity in the hydrocarbons.

In my researches upon the luminosity of flame I have shown that all the hydrocarbons present in coal-gas and other luminous flames are converted by the baking action taking place in the inner non-luminous zone of the flame into acetylene before any luminosity is produced, and that it is the acetylene which by its rapid decomposition at 1,200°C. provides the luminous flame with those carbon particles, which, being heated to incandescence by various causes, endow the flame with the power of emitting light. The acetylene, being in this way proved to be the cause of luminosity, one would expect that in this gas we have the most powerful of the gaseous hydrocarbon illuminants; and experiment at once shows that this is the case.

Owing to its intense richness it can only be consumed in small flat-flame burners, but under these conditions emits a light greater than that given by any other known gas, its illuminating value calculated to a consumption of 5 cubic feet an hour being no less than 240 candles.

Illuminating value of acetylene.

Illuminating Power of Hydrocarbons for a Consumption of 5 cubic feet of Gas.

	Candles.
Methane	5.2
Ethane	35.7
Propane	56 7
Eythelene	70.0
Butylene	123.0
Acetylene	240.0

COMMERCIAL ASPECT OF THE PROBLEM.

Data of cost of production.

Having arrived at this startling result it will be as well to at once turn to the commercial aspect of the problem, as it is upon this that the utilization of this magnificent illuminant is entirely dependent. At the present time private information from America shows that calcic carbide can be produced at a little under £4 a ton, and the beautifully pure lime obtained by the decomposition would be worth to the gas manager at least 10s. a ton; and as a ton of the carbide will give rather more than 1¼ tons of quicklime or 1¾ tons of slaked lime, £3 10s. may be taken as the cost of the acetylene produced from a ton of the material, and will leave a margin for handling. A ton of the carbide will yield in practical working 11,000 cubic feet of acetylene, which will bring the cost of the gas out at 6s. 4½d. per 1,000.

Enrichment values of oil gas

The cheapest and best enrichment process known at the present time is that introduced by Mr. Young, and which has been adopted at a number of gas works in Scotland and the north of England. In this process, by special methods of retorting, oils are decomposed to yield a rich gas, which in the photometer and burnt in suitable burners per se gives an illuminating value of about 60 candles, but for which an enrichment value of 96 candles is claimed. [See footnote p. 145].

I am desirous of understating rather than overstating the powers of the acetylene, so that instead of taking enrichment values for it which might be questioned, I prefer to simply take the illuminating power of the gas when burnt, per se, and the light measured in the photometer, which as before stated is 240 candles, whilst for the same reason we will take the claimed enrichment value of the Young gas, instead of its photometric value.

and acetylene compared.

An extended experience gained with the Young process, as used at St. Helen's for the enrichment of coal-gas, shows that the cost may be taken at 3s. 4d. per 1,000 cubic feet. If now we compare this with the acetylene at 6s. 4½d. per 1,000, we find that the 240-candle gas at this price would be equal to Young gas at 2s. 6½d. Moreover the Young plant to work a ton of oil per diem costs—according to the experience at Peebles—£1,500, and generates 22,000 cubic feet a day, the retorts for this purpose occupying a very considerable space; whilst to make the same volume of acetylene two tons of material would have to be handled, and the whole operation could easily be carried out in one small egg-ended boiler, fitted with an automatic water feed and automatic gas delivery valve to outlet of the main for the holder, so that the enriching gas could be added pro rata to the gas as it left the works in order to bring it up to any required strength, in the same way as is done with the Maxim-Clarke enrichment, and all the troubles of stratification in the holder would be done away with. For the first few hours the water in the consumers' meters would absorb small quantities of the acetylene, but quickly becoming saturated no further absorption would take place.

Minimizing the risk of explosion.

It is well known that acetylene forms two compounds with ammoniacal solutions of the metals silver and copper, and both of these compounds when dry can be readily exploded by percussion, friction or heat. In the early days of gas supply, copper pipes were used in New York, and Torrey in 1839 found in them a brown scaley deposit which exploded when struck or heated to 200° C., and which was in all probability acetylide of copper.

An extended series of experiments on this point show that when metals are kept in the gas, even if moisture be present, no action takes place unless water condenses on the metal when tarnishing with silver and copper, and to a less degree with brass, commences, and under these conditions an acetylide of mercury can also be formed, but the other metals remain unacted upon. If therefore iron, tin, lead, or compo pipes be used for the gas supply, no precautions are necessary. Copper and brass tubes must either be coated inside with some varnish not acted upon by the acetylene, or tin lined.

In America, which was the birthplace of this method of making calcic carbide, the acetylene is mixed with an equal volume of air and the mixture burnt at small slit burners; but I confess to a grave mistrust of this method of using the gas, as the margin of safety in the amount of air required to convert the mixture into an explosive is so small that the danger of exceeding it on any large scale must be very great, as any mistake or alteration in the mixing apparatus used for this purpose might easily bring the percentage of air up to the explosive limit, whilst the diluting action of the nitrogen of the air reduces the illuminating value of the acetylene present from 240 candles to 130.

SCOPE AND POSSIBILITIES OF THE DISCOVERY.

Storage of acetylene in the liquefied state.

The possibility of liquefying acetylene by pressures about those at which liquid carbon dioxide is produced so largely enables enormous volumes of this gas to be compressed into the liquid state in small wrought iron or steel cylinders, and in this condition by means of suitable reducing valves and burners of the right construction it may be stored and burnt. Used in this way, it will be of the greatest possible value for floating buoys, and the small cylinders can also be arranged in the form of portable lamps, whilst for use in the country, where no gas is available, a large cylinder of the liquid gas placed in an outhouse would supply a country house with light for a very long period; and there is no doubt that there is a very great field for it in this direction, as by utilizing suitable burners a consumption of half a cubic foot an hour will give a light equal to from 20 to 25 candles.

Perhaps the most valuable suggestion which has been made with regard to the utilization of this remarkable method of making acetylene is, that advantage should be taken of the method of preparation to utilize the body of portable lamps for dining and drawing-rooms in places where no gas supply exists. To do this a strong steel cylinder, 4 inches in diameter and 16 inches in length, is fitted with an opening in the top of such size that a pound cartridge, or stick of the calcic carbide, can be passed through it. The cylinder has a second opening at the bottom, closed by a screw for cleaning out the lime left by the decomposition. The right proportion of water is put into the cylinder, and the stick of carbide coated with a slowly soluble glaze is inserted and the head of the lamp screwed on. The head contains a double reducing pressure valve, which brings down the pressure existing in the cylinder to that necessary for the proper consumption of the gas, it also being fitted with a valve. As the glaze dissolves from the surface of the stick of carbide acetylene is generated, and the five cubic feet are compressed by their own pressure, the cylinder being placed in a vessel of cold water whilst the gas is generating, and the gas can then be burned from a suitable jet at the rate of half a cubic foot per hour, which will give a light of over 20 candles for something like 10 hours. When the gas is all burnt out from the cylinder the top of the lamp is screwed off, the bottom plug also removed, and the lime washed out from the interior of the cylinder by a rapid stream of water. The cylinder is then recharged as before. Used in this way also this gas would rapidly replace oil gas for railway lighting, as the fittings at present in use for the Pope and Pintsch systems would answer perfectly well for the purpose of using acetylene, the only difference being that the cylinder placed below the carriage, which under the present conditions is filled with compressed oil gas, would be utilized not only as a storing but as a generating vessel for the acetylene, the highly expensive oil gas manufacturing and pumping plant being done away with, and a magnificent illumination ensured in the carriage.

A simple method of using the gas in houses

and in railway coaches.

Of late years an idea has been slowly permeating the minds of some gas managers in this country that it might be well to adopt a dual gas supply, one for fuel purposes, which would consist of a poor coal-gas of about 12 candles, whilst the gas for illuminating purposes would be of about 20 candles; and in one town at least it has been proposed, and I believe carried out, that a supply of poor quality coal-gas should be sent out during the day, when the maximum consumption is for heating purposes, and a richer gas at night for illuminating purposes, utilizing the same mains for both. Although this is possible in a small town where the area to be supplied is not large, it would be impossible in a big town where many miles of huge mains have to be travelled before certain districts are reached, and the cost of a double set of mains would render a dual supply an impossibility.

The use of acetylene would render it possible for the gas company to send out a 12-candle gas for heating purposes, both by night and day, whilst a small enrichment cylinder might be attached to the gas outlet pipes from the consumer's meter, and this would be made to automatically enrich the gas supplied to his house, so that by setting a valve he could have any quality he might desire.

Comparison by illuminating power.

The economic value of an illuminant such as acetylene becomes apparent when we compare the cost of the gas for equal illumination with the light obtained from other illuminants. The London gas has an illuminating power of 16 candles, whilst the acetylene has an illuminating value of 240 candles, and this at 6s. 4½d. per 1,000 would in light-giving value be equivalent to London coal-gas at less than 6d. per 1,000.

In order to obtain a given illumination, moreover, the volume of gas to be consumed is excessively small, as compared with any other illuminating gas, and the products of combustion are reduced to an excessively low limit. One hundred cubic feet of London coal-gas will yield 50 cubic feet of carbon dioxide and 140 cubic feet of water vapor as the products of its complete combustion, whilst 100 cubic feet of acetylene would yield 200 feet of carbon dioxide and 100 feet of water vapor. The acetylene however in its combustion gives a light of 240 candles, as against 16 yielded by the coal-gas; and for equal illumination therefore the amount of carbon dioxide and water vapor produced is enormously smaller.

The following table contrasts the products of combustion evolved from London coal-gas, when consumed in various forms of burners and giving an illumination of 48 candles, which may be presumed to be the amount of light required in a fair-sized London dining-room, and contrasted with this is the amount of the products of combustion which acetylene would evolve in giving the same amount of light; whilst to make the meaning clearer, I have added the number of adults who would exhale the same amount of carbon dioxide in the same time.

Burner.	Gas consumed.	Carbon dioxide produced.	Adults.
Flat flame, No. 6	19.2	10.1	16.8
Flat flame, No. 5	22.9	12.1	20.1
Flat flame, No. 4	25.3	13.4	22.3
London Argand	15.0	7.9	13.1
Acetylene	1.0	2.0	3.6

If we obtained the same amount of light from paraffin lamps, the carbon dioxide evolved would be equivalent to 22.5 adults; whilst as far as carbon dioxide goes you might as well invite 32.7 guests to dinner as use 48 sperm candles to supply the needed illumination.

Temperature of the acetylene flame.

The flame of acetylene in spite of its high illuminating value is a distinctly cool flame, and in experiments which I have made by means of the Le Chatelier thermo-couple, the highest temperature in any part of the flame is a trace under 1,000°C., whilst with coal-gas burning in the same way in a flat-flame burner the temperature rises as high as 1,360°C. If the heating effect of the flames be contrasted for equal illumination, it will be seen that the acetylene flame has so small a heating effect, considering its area, that it would not be much greater than the ordinary electric incandescent lamp

The intensity of the light will make small acetylene lamps of enormous value for lantern projection, for railway signals, and, coming down to smaller things, bicycle lamps, whilst I should imagine the ease of production specially adapts it for such purposes as lighthouse illumination.

Outlook of the discovery along other lines.

The scope and possibilities of such a discovery as that which I have brought before you this evening cannot be realized until many factors at present unknown are thoroughly worked out, and you must remember also that the time at my disposal has only enabled me to bring before you to-night some facts connected with the light-giving value of this hydrocarbon, and that as a stepping-stone to the synthesis of other bodies its value will be incalculable. One cannot help feeling that as science grows, and as our grasp and comprehension of the marvellous processes by which nature builds up her matter become more and more extended, synthesis may have even greater conquests to make than the mere building up on a commercial scale of an illuminating hydrocarbon.

We are beginning to realize more and more fully the marvellous way in which nature keeps matter in circulation, the way in which animal and vegetable structures are built up from the simplest and most plentiful substances, and the way in which, when the structure is done with, those processes of slow combustion which we call decay again convert the waste bodies into carbon dioxide and water vapor, from which once more nature reconstructs the vegetable and animal kingdom; and it may be that as our perception of the methods of that marvellous natural architecture gets clearer and keener, we may discover how, by simple synthetic processes, the carbon dioxide and water vapor which form nature's building material may be synthetically utilized by us in building up, not the perfected form of man, or animal, or plant, but the building on a commercial scale of the food which is required by nature for carrying on the functions necessary for life. [5]

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[5] The London Journal of Gas Lighting made the following comments on Prof. Lewes' paper and the experiments with which it was illustrated:

"The time was Wednesday, January 16th; the place the well known lecture theatre of the Society of Arts, London; the man, Professor Vivian B. Lewes, and the matter Commercial Acetylene. From this combination resulted, then and there, a sensation which, unless appearances are utterly illusory, will echo and re-echo through the industrial world for a very long time to come. When the announcement was made that Professor Lewes would read a paper on 'The Commercial Synthesis of Illuminating Hydrocarbons,' no indication was given of the particular turn which the communication would take, but that a high degree of interest and importance would be found to attach to Professor Lewes' matter was foreshadowed by the steps taken with the co-operation of Sir H. Trueman Wood, the Secretary of the Society, to secure a fit audience for the occasion. In consequence of this effort, a goodly contingent of gas engineers and others interested in the gas industry put in an appearance at the Society's house last Wednesday evening; but it is not to be supposed that a single individual among this critical portion of the audience had the faintest expectation of what was coming, or entertained the slightest idea that he was about to assist at what will in all probability come to be regarded throughout the gas and the allied interests as an epoch-making demonstration. Professor Lewes' and the Society's secret was perfectly kept, and its disclosure at the proper time was therefore all the more astounding. For his design was no other than the first exhibition to the world of one of the most striking of the fruits of modern scientific discovery in the new territory of physico-chemistry, the product of that remarkable research of Mr. T. L. Willson—carbide of calcium—the nature and properties of which were by a pure coincidence described in our last week's Technical Record. The absorbing interest of this programme, and the brilliant manner in which it was carried out, are not likely to fade from the minds of those who had the good fortune to attend on this historic occasion.

"What Professor Lewes said will be found reported in full in another column. Our present purpose is to draw attention to the text of the paper and to supplement it with independent testimony as to the demonstrations by which the lecturer proved his statements. He commenced by laying out the ground for the structure he was about to raise, inviting the attention of his audience to the twin methods of chemical research, analysis and synthesis, to make it quite plain that he was not going to ask them to take from him anything arrived at by occult means or needing to be hedged about by the devices of charlatanry. Only too often in the history of so-called new discoveries in chemical industry, there is something

THE CARBIDES AND ACETYLENE COMMERCIALLY CONSIDERED.[6]

By T. L. Willson and J. Suckert, Ph.D.

Methods of formation, and chemical and physical properties of the compounds.

Before entering upon the subject matter of this paper, namely, the commercial consideration of the carbides and acetylene, we believe that a brief history of these compounds, their methods of formation and their chemical and physical properties, will be of interest to you. That carbon will combine directly with various metals under the influence of heat has long been known to chemists, but these compounds, generally known as 'carbides,' have been but imperfectly studied, and, with the exception perhaps of the carbides of iron, are hardly known.

Carbides of the alkali and alkaline earth metals,

The only group of carbides which interests us this evening is that of the carbides of the alkali and alkaline earth metals, such as the potassium, sodium, barium, strontium and calcium carbides; for the reason that these are the only carbides which when brought into contact with water will decompose it, forming generally the hydrated oxide of the metal and acetylene gas. Of these latter carbides, the combination of calcium with carbon has the greatest commercial possibilities on account of the low first cost of the raw materials which enter into this combination, namely, lime and coal, the abundant

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kept back. The result, whatever it is, is stated to be attained by the employment of some 'chemical,' the nature of which is not disclosed. Of course a man of reputation in science does not mix himself up in such schemes; but things of this kind occur often enough to point the observation we now offer regarding the transparency of Professor Lewes' exposition. And when the lecturer had by easily followed steps arrived at the top of the first stage of his structure—the announcement that it was the synthesis of acetylene in bulk which it was his purpose to deal with—he was careful to show that there is nothing absolutely new about carbide of calcium or the phenomenon of its giving off acetylene when wetted with water. He carefully told the story of the early experiments with this compound; and only 'let himself go' in the capacity of the exhibitor of a new thing when he came to deal with the production and uses of it on a commercial scale by the method of Mr. Willson.

"And a very startling exhibition it was—as utterly fresh and convincing as good matter in the hands of a master in the art of science exposition could make it. Carbide of calcium as known to science, was a chemical curiosity until Mr. Willson happened upon a way of preparing it in bulk in the course of his experiments upon the manufacture of calcium alloys by the agency of his electrical furnace. But this discovery put a new face upon the compound. When an article that has only existed in grains comes to be turned out by the ton, it is to all intents and purposes a new article. In this sense carbide of calcium is very new indeed; and its industrial possibilities are newer still, inasmuch as only the most direct and obvious of these developments have as yet been so much as hinted at.

"Take it that the material can be produced by the ton, and it is impossible to surmise what chemical industry will be able in the fulness of time to make of it. The product of fusing together in an electrical furnace such common materials as lime and carbon in any suitable form was exhibited by Professor Lewes as a greenish-gray stone-like substance greatly resembling the commonest description of serpentine rock. When kept in the air a light coating of lime soon forms on its surface. Upon handling it a faint, unpleasant odor, suggestive of garlic, and also not altogether unlike the familiar reek that emanates from the ironwork of an old gas-purifier, manifests itself. To all appearance it is a dull, inert stone, devoid of any other properties than those of common road metal, and not much likely to be credited by the casual observer with gas yielding capabilities. Upon a piece of this material Professor Lewes sprinkled a few drops of water from a wash bottle, and put a lighted taper to it. The nascent gas—acetylene—immediately ignited with more than the brilliancy of the pitchy flame of highly bituminous coal in an open fire, and continued to burn fitfully over the wetted surface until all the water was gone. Then came the display of the same gas evolved in a jar (standing upon the lecture table), which contained pieces of the carbide in water and stored in make-shift glass holders. It was a dramatic denouement of Professor Lewes' little plot when he applied a light first to a single open flat-flame burner, and then to a group of five similar burners, and people saw for the first time in a public place the intensely brilliant white and solid looking flame of burning pure acetylene.

"It is indeed a flame to wonder at. Nothing like it ever before came within the ken of a gas manager or dazzled the vision of a photometrist. There is something startling in the suggestion that gas of 240 candle power—calculated in accordance with photometrical practice, upon the basis of a consumption of 5 cubic feet per hour—can be burnt by means

[6] A paper read at the Franklin Institute, Philadelphia, March 20th, 1895.

deposits of same in all quarters of the globe, and the commercial value represented by the by-product, hydrate of lime, which is obtained in large quantities by the decomposition of the calcium carbide with water.

and their history.

The history of the discovery and methods of production of this group of carbides may briefly be stated as follows:

The first authentic reference to this subject was the discovery by Sir Humphrey Davy that carbon and potassium, when heated to a temperature sufficiently high to vaporize the potassium, formed a compound which after cooling would effervesce with water.

Berzelius in 1836 determined that the black substance formed in small quantities as a by-product in producing potassium from potassic carbonate and carbon was carbide of potassium.

Woehler in 1862 prepared calcium carbide by fusing an alloy of zinc and calcium with carbon, and ascertained that it decomposed by contact with water, forming calcic hydrate and acetylene.

Berthelot in 1866 described sodium carbide or acetylene sodium. He produced it by the following method: Metallic sodium, when slightly heated in acetylene gas, puffs up and absorbs acetylene with the formation of the compound C_2HNa. At a dull red heat sodium destroys acetylene, forming a black carbonaceous mass, C_2Na_2. The reaction is expressed by the following

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of an open flat-flame burner. When the carbide of calcium first came into Professor Lewes' possession this had not in fact been done, and in order to get a flame of acetylene at all the American handlers of the gas had fallen back upon the brutal device of diluting it with a certain proportion of air. This was to repeat the crude American way of rendering naphtha gas usable. But the dilution of acetylene with air is even more objectionable than is the same treatment in regard to naphtha gas, inasmuch as it is more easily converted into a violent explosive mixture. Professor Lewes, in succeeding in burning acetylene in the pure state in which it comes from the mixture of calcium carbide and water, has saved its prospects as an illuminant. He showed on Wednesday those wonderful acetylene gas flames already mentioned, each produced by burning the gas as made in the simple way described, without any adventitious mechanical or chemical aid, after the rate of half a cubic foot per hour, and stated to yield a measured illuminating power of 25 candles. This could easily be credited. But what it is more difficult to convey in mere words is the impression of steadfastness, whiteness and, so to speak, solidity which the flames in question made on the observer. At a little distance no non luminous zone could be perceived, but on a close inspection a tiny speck of blue over the top of the burner was visible. No smoke or smell escaped from these flames, which, although exhibiting in their color the evidence of intensely active combustion, were found to be much cooler than oil-gas or albo-carbon gas flames of the same size. This is a most striking feature of free burning acetylene. The incandescent electric lamps of normal brilliancy by which the lecture theatre was lit were made to look as dull as 'red-hot hair-pins' by the aggressive acetylene, which itself by virtue of the irradiation produced by its dazzling white flame appeared to form balls of almost blinding light when viewed directly in face or sideways of the flame. The mantle of the incandescent light is no whiter than, if it is so white as, the naked acetylene flame, which does not flicker or change color; but in the absence of means of making a direct comparison between the two lights it is rash to say which would bear the palm for purity of tint.

"It is not for us to say what may be done with this new servant of a community that ever clamours for more light, and gets it more easily and cheaply every day. Considerations of the cost at which the carbide of calcium will be producible, and of the prospects of its utilization as a means of generating portable gaslight or as an enricher of common coal gas, suggest themselves to every one who sees or hears of the substance and its qualities. But it is premature to discuss such questions at present; all that need be said upon these points for the time being was said on Wednesday by Professor Lewes, and by those who took part in the extremely cogent little discussion that followed his brilliant discourse. When the time is ripe for more it will doubtless be forthcoming. Meanwhile it is only doing justice to all the parties concerned in last Wednesday's memorable proceedings in the Adelphi to acknowledge the high interest of the whole subject, and the adequate manner in which it was presented to the general and technical public. The discoverer of the system is to be congratulated upon the promise of the new industrial development; Professor Lewes may be complimented upon the deft and convincing way in which he performed the part of introducer of the novelty; and—if last not least—the Society of Arts deserves to be credited with having proved once more the practical value of the agency wielded by the council and secretary of this useful institution for giving publicity readily and promptly to warrantable novelties in science and the industrial arts."

formula: ($C_2H_2 + Na_2 = C_2Na_2 + H_2$). This compound, C_2Na_2, in contact with water, regenerates acetylene.

A stage of non-progress.

From 1866 until 1888, a period of twenty-two years, nothing further has been recorded of scientific work done in this direction; as a matter of fact, the compounds so produced were not only very impure, but their cost of production also was so great as to render their commercial use prohibitory; they were considered as curiosities, and looked upon by scientists as such.

Willson's experiments with the aid of an electric furnace,

In 1888 Mr. T. L. Willson began a series of experiments relating especially to the reduction of refractory metallic oxides by carbon in an electrical furnace. By this method the reductions were to be accomplished by the heat effect of the current alone, and not by electrolytic action.

and the various results obtained.

The results of these experiments, which were numerous, and which extended over a period of years, developed some very interesting data as to the action of intense heat on refractory bodies generally, and especially as to the formation of carbides in large quantities. Mr. Willson found that lime, baryta, strontia and even alumina, when subjected to the intense heat of his electric furnace, were liquefied and formed a molten mass, which could be brought to ebullition. An addition of carbon thereto caused a decomposition of the oxide, carbon monoxide being formed, while the fused metal united instantly with the excess of carbon previously introduced to form a carbide. Further experiments developed the fact that when a mixture of powdered lime and coke dust was introduced into the furnace the mixture would melt down to a thick syrupy mass of practically pure carbide of calcium, and that this when removed from the furnace and brought in contact with water evolved acetylene gas in large quantities. The carbides of barium, strontium and aluminium also were prepared in the same manner, and the specimens now before you are the results of these earlier experiments.

Fig. 1.

We will now introduce a small quantity of each of these carbides into different vessels containing water at ordinary temperature. The carbides of barium, strontium and calcium decompose water readily, forming the respective hydrates of their metallic oxides and acetylene gas, which we now ignite as it is being evolved in each vessel; the resulting gas, as you observe, burns with a luminous sooty flame (see Fig. 1). As the carbide of aluminium does not react with water at ordinary temperatures, no gas is evolved from the fourth vessel.

This substantially completes the history of the alkali and alkaline-earth metal carbides up to the date of Mr. Willson's discovery.

CARBIDE OF CALCIUM AND ACETYLENE.

Properties of pure calcium carbide.

The physical and chemical properties of pure calcium carbide, as first prepared in the Willson furnace, and which we now hand you for inspection, are those of a dark brown, dense substance, having a crystalline metallic fracture of blue or brown appearance, and a specific gravity of 2.262; it evolves a peculiar odor when exposed to the atmosphere, due to the action of atmospheric moisture. In a dry atmosphere it is odorless. When exposed to the air in lumps it becomes coated with a layer of hydrate of lime, which to a great extent protects the rest of the substance from further deterioration by atmospheric moisture. It is not inflammable, and can be exposed to the temperature of the ordinary blast furnace without melting. When exposed to the flame of a Bunsen blast lamp it can be heated to a white heat, the exterior only being converted into lime. When brought into contact with water or its vapors at ordinary temperatures, it is rapidly decomposed, one pound generating when pure 5.892 cubic feet of acetylene gas at a temperature of 64° F. It also decomposes with snow at a temperature of — 24° F. It is not acted upon by the vapor of water at high temperatures. It abstracts moisture readily from alcohol, also from liquefied ammonia gas, rendering the latter anhydrous. If small pieces are treated with common sulphuric acid, a violent reaction ensues. Acetylene is generated with considerable increase in temperature. If however large pieces are plunged into common sulphuric acid, the reaction is feeble.

An exhaustive series of experiments made by Dr. H. Schweitzer of New York have shown that when treated at a red heat with dry muriatic acid gas, the carbide is decomposed with the formation of free carbon and small quantities of a yellow substance easily soluble in ether. When treated with steam at different temperatures, (up to 428° F.), and different pressures (up to 35 atm.), the material was decomposed with the formation of but small quantities of the same yellow substance, and not in sufficient quantity for further examination.

Benzol, nitro-benzol, phenol, aniline, toluidine and other organic compounds gave no reaction when treated with carbide of calcium alone, and in the presence of water, at varying pressures and temperatures. It would appear from the foregoing to be a very inert body in its action on other compounds, and in view of this fact the ease with which it decomposes water at ordinary temperatures is remarkable.

Acetylene gas,

When treated with water in a closed vessel properly cooled, acetylene gas continues to be evolved from the material at pressures exceeding 75 atm. Calcium carbide has the chemical formula CaC_2, and contains in 100 parts 62.5 parts of calcium and 37.5 parts of carbon.

its composition

The gaseous product of the decomposition of the alkali and alkaline earth metal carbides with water, namely, acetylene, is an unsaturated hydrocarbon of the series C_nH_{2n-2}, having the chemical formula C_2H_2, and containing therefore in 100 parts 92.3 parts of carbon and 7.7 parts of hydrogen.

and history.

It was first recognized and its chemical constitution determined by Berthelot in 1849. It has heretofore been formed in small quantities by passing ethylene, or the vapors of alcohol, wood alcohol, ether and other organic compounds through a red-hot tube. It is present in coal gas to the extent of 0.06 per cent., and water gas contains almost 1.0 per cent. It has also been formed by passing hydrogen gas between carbon points brought to incandescence by the electric current, which is the first recorded synthesis of an organic compound directly from its elements. It can also be produced by the incomplete combustion of the vapors of ether, amylene, etc.; or of illuminating gas, in the interior of a Bunsen burner; by passing the vapor of chloroform over red-hot copper; or from chloroform and potassium amalgam; or from chloroform and sodium; or by the electrolysis of fumaric and malic acids; by passing the vapor of ethylene chloride over red-hot soda lime, and finally, by allowing ethylene bromide to drop in a boiling concentrated solution of alcoholic potash, passing the impure acetylene into an ammoniacal cuprous chloride solution, washing the red precipitate with water, and whilst still moist boiling it with concentrated hydrochloric acid.

Properties of the gas.

Acetylene is a colorless gas, having a penetrating pungent odor somewhat resembling garlic, which is of great importance in its application to household illumination, as it renders the slightest escape of gas in a room easily detectable. It has a specific gravity of 0.91, and burns with a luminous sooty flame. It is soluble in water in about the same proportions as carbon dioxide, that is, at 64° F. water will absorb its own volume of the gas. Absolute alcohol and glacial acetic acid dissolve about six times their volume. It is practically insoluble in saturated brine, 100 volumes absorbing but five volumes of the gas, whereas paraffin will absorb two and one-half times its volume. By heating acetylene to the softening point of glass, benzol (C_6H_6), styrolene (C_8H_8), naphthalene ($C_{10}H_8$), anthracene ($C_{14}H_{10}$), and reten ($C_{18}H_{18}$), are formed.

With an alkaline solution of permanganate of potash acetylene is oxidized to oxalic acid, and with a dilute solution of chromic acid to acetic acid. By treating acetylene copper with zinc and ammonia ethylene is formed, and a mixture of acetylene and hydrogen brought in contact with platinum black forms ethane. By the electric spark acetylene is resolved into carbon and hydrogen, at the same time a fluid and a solid poly-acetylene are formed; the latter resembles horn, and is insoluble in the ordinary solvents A mixture of nitrogen and acetylene is converted by the induction spark into hydrocyanic acid.

It may be heated to a temperature of 370° F., and under a pressure of 43 atmospheres, without decomposition.

May be condensed into a liquid.

The gas can readily be condensed to a liquid, as is evidenced by the following table, the pressures being considerably less than those required for carbon dioxide:

Acetylene.		Carbon dioxide.	
Fahr.	Atmospheres.	Fahr.	Atmospheres.
— 116.°	1.0	— 112.°	1.0
— 28.6	9.0	— 23.2	12.7
— 9.4	11.01	— 4.	19.93
+ 14.	17.06	+ 14.	26.76
32.	21.53	32.	35.40
41.45	25.48	41.	40.47
56.3	32.77	59.	52.17
67.27	39.76	68.	58.84

Pressures and specific gravities.

The critical point of the gas has been placed by Ansdell at 98.69° F. He also determined the specific gravity of the liquefied gas at various temperatures, placing the density at about one-half that of carbon dioxide; but his results do not agree with those obtained by us in the production and storage of large quantities of the liquefied gas. For instance, the small tank to which this connecting pipe and burner are attached (Fig. 2) should contain according to Ansdell, when filled at 69.08° F., about 2.15 pounds of liquefied acetylene; as a matter of fact however we can fill into this tank somewhat more than two and three-quarter pounds of the liquefied gas. We are now engaged in preparing a new table of pressures and specific gravities of the liquefied gas, and will be pleased to communicate the results to you at a later date. One pound of the liquid when evaporated at 64° F. will produce fourteen and one-half cubic feet of gas at atmospheric pressure; or a volume 400 times larger than that of the liquid.

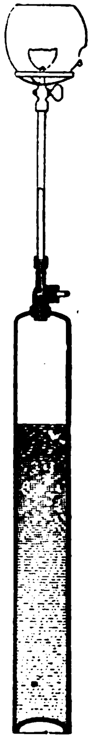

Fig. 2.

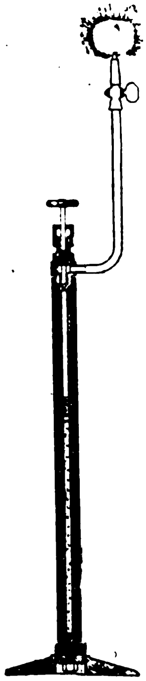

Fig. 3.

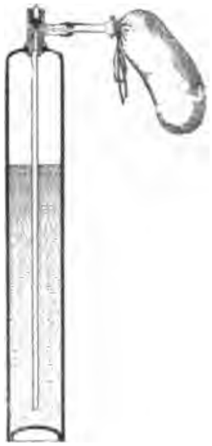

Fig. 4.

Fig. 5.

Liquefied gas.

The odor of the gas has already been made apparent to you whilst the experiment showing the decomposition of the various carbides with water was being carried on. We will now show you the liquefied gas contained in this glass tube surrounded by a metal casing (Fig. 3). As you will observe, the liquefied gas forms a colorless, mobile, highly refractive liquid, which when the pressure is slightly relieved commences to boil and evolves a gas which, ignited as it issues from this gas tip burns with an intensely white flame. If the liquefied gas be suddenly relieved of its pressure, or allowed to escape in its liquefied state to the atmosphere, a portion evaporates rapidly, thereby abstracting from the remaining portion sufficient heat to solidify it. This tank, which is now shown you (Fig. 4), contains liquefied acetylene, which has been cooled to a temperature of —28° F. in order to prevent the escape of too large a volume of gas during the process of its solidification. Attached to this valve, inside of the tank, is a tube which reaches within half an inch of the tank bottom, and is open at its lower end. We now attach to the valve a flannel bag to receive the solidified gas. Upon opening the valve the liquefied gas escapes, the solidified portion remaining in the bag, while the gas formed escapes through the pores of the bag. This bag will hold about three-quarters of a pound of the solidified gas, and this is about the quantity which is now being emptied on the plate. A portion of this solidified gas will now be passed to you for inspection; another portion is packed into this wooden tube, a thermometer is inserted (Fig. 5), and, as you will observe, the temperature falls to — 118° F. Another portion is placed on one pound of mercury contained in this saucer (Fig. 6); the intense cold of the solidified gas almost immediately solidifies the liquid metal. A portion of the solidified gas or "acetylene snow" is now dropped into this vessel (Fig. 7), containing water. Being lighter than water it floats upon its surface, and when touched with a light the gas surrounding each particle of the solidified gas burns with a sooty flame, and continues to burn until all the solidified gas has disappeared.

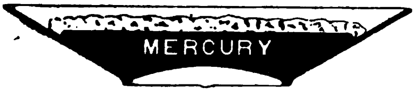

Fig. 6. Solidified gas.

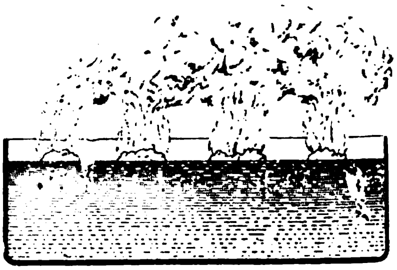

Fig. 7. Flame of solidified gas.

Acetylene snow, or solid gas.

I will now ignite the gas evolving from the acetylene snow contained in this dish, and you have the interesting exhibit of a solidified gas at — 118° F. giving off gas which can be ignited, and which, although evolved at this low temperature, possesses the same illuminating power as at higher temperatures.

You have now seen acetylene in its three physical conditions, namely, as a gas, a liquid and a solid; and the mere fact that it readily assumes the gaseous and liquid condition is of vital importance to its commercial application.

COMMERCIAL APPLICATION OF THE COMPOUNDS.

Experiments to determine commercial value in other directions.

Having described the physical and chemical properties of calcium carbide and the product of its decomposition with water—acetylene—we will now consider the commercial possibilities of these compounds.

Carbide of calcium, as we have already shown, is a rich source of acetylene, but beyond this we cannot at present definitely designate additional commercial applications of this material.

Extended experiments are now being conducted to determine its commercial value in the production of cyanides and various nitrogenous compounds, in the manufacture of iron, steel and other metals, and their alloys, and in its application to the synthetical formation of various organic compounds.

The results thus far obtained however, although encouraging, do not as yet justify us in accepting them as commercially applicable.

Method and cost of production.

As the commercial value of any material largely depends upon its cost of production, its purity and the value of the products and by-products obtained therefrom, our first consideration will be the method of manufacturing the carbide of calcium and the cost of the finished product.

The carbide of calcium originally prepared by Mr. Willson during his first experiments was produced at a cost largely in excess of that for which it can be manufactured to-day, but a description of these original experiments will without doubt be of interest to you.

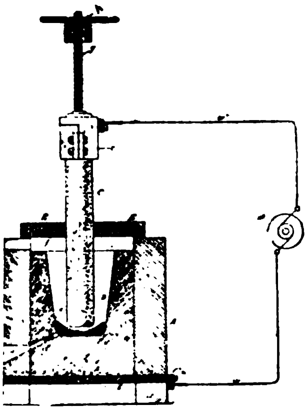

Fig. 8. Furnace for producing calcium carbide.

Description of the first electric furnace used,

The first experiments were made with a dynamo generating a current of 150 ampères at from 60 to 70 volts. The furnace consisted of a plate of carbon 12 inches square and one inch in thickness, along one edge of which an iron rod was bolted and projected beyond the mason work, and to which one terminal from the dynamo was connected. This carbon plate was embedded in brickwork, having only a small central portion exposed, upon which the graphite crucible rested. From one terminal of the dynamo the current was conducted through the iron rod, carbon plate, graphite crucible, the material to be acted upon, and the carbon pencil, to the other terminal. To start the furnace, the pencil was placed in contact with the bottom of the crucible and the dynamo was started up slowly. As the electromotive force increased the pencil was withdrawn from the bottom of the crucible and the 'arc' established.

The material to be acted upon was then introduced through an opening in the cover of the crucible, the cover being either of non-conducting material, or, if of graphite, insulated from the crucible by a non-conducting luting. One of the pencils from the original lot used in these earlier experiments is now before you. This carbon pencil is 12 inches long, 1¼ inches in diameter, copper-plated and has a hole bored through its entire length, the tube so formed being used for the introduction of gaseous agents. With this furnace various metallic compounds, intermingled with pulverized carbon and also surrounded by gaseous reducing agents, were subjected to the intense heat developed by the electric arc.

and of the second furnace.

The success attending the operation of this first furnace, in the reduction of refractory metallic oxides, justified the continuation of the experiments upon a larger scale, and to this end the Willson Aluminum Company was organized and a plant erected at Spray, North Carolina. This plant was supplied with a dynamo, operated by water power, and generating a current of 2,000 ampères at 35 volts. The furnace was constructed as here shown (Fig. 8), namely:

A designates the outer masonry shed or bench of the furnace; *B* the carbon or graphite crucible or hearth; *C* the carbon bar or pencil constituting the moveable electrode, and *D* the dynamo for generating the current. From the terminal brushes of this dynamo one wire, *w*, leads to and communicates with the crucible *B*, while the other wire, *w′*, leads to and communicates with the carbon pencil *C*. The connections are usually made in the manner shown, the wire *w* being connected through a fastening-bar *a* to an iron plate *b*, underlying the crucible *B*, and the wire *w′* being connected to a metal socket *c*, embracing the upper end of the carbon pencil *C*. The bench *A* is generally made of firebrick, which is a non-conductor of electricity, and the furnace is covered with a plate or, preferably, two plates, *EE*, of carbon, having a central hole through which the carbon pencil *C* projects down into the crucible.

For tapping out the resulting product a tap-hole *d* is formed, which in operation is closed by a plug *e*, of clay or other suitable refractory material. The carbon plates *EE* rest on the top of the firebrick walls *A*, which project above the top of the crucible, forming an intervening space *f* for the furnace, between *B* and *E*. For the vertical adjustment of the carbon pencil a screw-threaded shaft *g* is provided, which may be moved up and down by the engagement therewith of a suitably mounted rotative nut *h*.

First run of the furnace.

The first carbide of calcium produced in this furnace, in accordance with memoranda taken at the time by Mr. Willson, was manufactured as follows: A mixture of lime and tar was boiled in a caldron, in the proportion of 60 pounds of lime to 11 gallons of coal-tar, and the heating was continued until the mixture was perfectly dry. It was then introduced into the furnace and subjected to the heat of the electric arc for a period of two hours, gradually feeding the mixture of lime and tar to the furnace as fusion took place. The product obtained consisted of a purplish-yellow mass, which in contact with water evolved acetylene gas. A sample of the calcium carbide produced upon this occasion is now before you, and represents the first calcium carbide produced in an electrical furnace.

The experiment was repeated with a mixture of 15 pounds of tar in fused lime and alumina, the time required for the operation being one and one-half hours.

The product obtained was a black, crystalline mass, consisting of a double carbide of calcium and aluminium. A sample of this double carbide is also submitted for your inspection.

Another run, made with a mixture of 10 pounds of lime and 10 pounds of finely divided carbon, operating one hour, resulted in the production of a dark crystalline mass, showing at its fracture black and blue crystals. A small metallic ingot was found in this mass, and a similar ingot of this white metal is now before you.

A fourth test, made with 17½ pounds of lime and 17½ pounds of carbon, resulted in obtaining 11 pounds of almost pure calcium carbide.[7]

Successful results obtained.

The tests described represent but a few of the numerous experiments conducted by Mr. Willson in his efforts to successfully and economically produce calcium carbide on a large scale. Recent results in the application of the alternating current to its manufacture prove conclusively that calcium carbide of a remarkable purity can be commercially produced. The product now being manufactured, in quantities exceeding one ton per diem, will readily evolve in contact with water $5\frac{3}{4}$ cubic feet of acetylene gas per pound of the carbide used, a result closely approaching to that which is theoretically possible, namely, $5\frac{98}{100}$ cubic feet per pound of carbide.

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[7] A sample of the carbide obtained during the last test was sent by Mr. Willson to Lord Kelvin of Glasgow University, and in return the following reply was received:

The University, Glasgow, October 3, 1892.

Dear Sir:—I have seen and tried the calcium carbide, only however so far as throwing it into water and setting fire to the gas which comes off. It seems to me a most interesting substance and I thank you very much for sending it to me. Yours very truly,

Thomas L. Willson, Esq. KELVIN.

Theoretical proportions.

The theoretical proportions of lime and carbon required for the production of 100 pounds of calcium carbide are, $87\frac{1}{2}$ pounds of lime and $56\frac{1}{4}$ pounds of carbon. Of the latter $37\frac{1}{2}$ pounds combine directly with the metal calcium ; and $18\frac{3}{4}$ pounds combine with the oxygen of the lime, and escape from the furnace as carbon monoxide, in accordance with the following formulæ :

$$\begin{array}{rcll}
CaO + C_3 & = & CaC_2 & + CO \\
87\frac{1}{2} + 56\frac{1}{4} & = & 100 & + 43\frac{3}{4}\ \text{(lb.)} \\
CaC_2 & = & Ca & + C \\
100 & = & 62\frac{1}{2} & + 37\frac{1}{2}\ \text{(lb.)} \\
CO & = & C & + O \\
43\frac{3}{4} & = & 18\frac{3}{4} & + 25\ \text{(lb.)}
\end{array}$$

Data for estimating quantity and cost of production.

A further element of cost in its manufacture is the production of heat in the furnace by means of the electric arc. Extended experiments in this direction have shown that one electrical horsepower will readily produce twenty pounds of calcium carbide each twenty-four hours, and the present indications justify the assumption that with automatically-fed furnaces, properly insulated to retain the heat, and by utilizing the waste heat to increase the temperature of the material acted upon, the production of calcium carbide can be increased on a large scale to thirty pounds per electrical horsepower each twenty-four hours.

By using limestone and coal dust, the latter being practically a waste product (not at present utilized), it is believed that calcium carbide can eventually be produced at a cost of less than $5 per ton. Where bituminous coal is employed, the value of the by-products obtained by its conversion into coke will largely reduce the cost of manufacture.

The hydrate of lime obtained from the decomposition of the carbide with water can be used again in the manufacture of the carbide, or it can be employed in the manufacture of ready-mixed mortar, which is already quite an industry in this city.

Arrangements to utilize electric power at Niagara Falls to manufacture calcium carbide.

Arrangements are now being made by the Electro-Gas Company of New York city with the Niagara Falls Power Company to apply 1,000 electrical horse-power to the manufacture of calcium carbide, which is shortly to be increased to 5,000 horse-power, and eventually we will without a doubt see the entire available power the company now possesses converted into electrical energy for the manufacture of this product. The effect of such a production would be far-reaching, and the economies resulting therefrom, if stated to-night, appear exaggerated and visionary. Assuming that but 20 pounds of the carbide are produced per indicated horsepower each 24 hours, then the amount manufactured during 300 working days would be 3 tons per horsepower per year ; and, applying 100,000 horsepower to its production, the annual output of such an establishment would be 300,000 tons. From this amount of material 3,300,000,000 cubic feet of acetylene gas should be produced, and as its illuminating power compared with ordinary illuminating gas of 25 candle-power is as ten to one, it would represent fully 33,000,000,000 cubic feet of this gas—an amount which would probably equal the annual output of the entire gas industry of the United States.

As this is but one of the many applications of the product obtained by the decomposition of the carbide with water, the manufacture of the carbide itself must of necessity become a large industry.

Contents of the calcium carbide.

As we have previously informed you, pure calcium carbide contains in 100 parts 37.5 parts of carbon and 62.5 parts of calcium, and when brought in contact with water acetylene is generated to the extent of 5.89 cubic feet of the gas to each pound of carbide used; or if compared by weight, 100 pounds of calcium carbide and 56.25 pounds of water evolve 40.63 pounds of acetylene gas, and form 115.62 pounds of calcic hydrate, in accordance with the following formula:

$$\begin{array}{c} CaC_2 + 2H_2O = CaOH_2O + C_2H_2 \\ 100 + 56.25 = 115.62 + 40.625 \text{ (pounds.)} \end{array}$$

The acetylene gas so generated contains in 100 parts 92.3 parts of carbon and 7.7 parts of hydrogen, or in the 40.625 pounds generated from 100 pounds of carbide, we have 37½ pounds of carbon and 3⅛ pounds of hydrogen. The entire carbon contained in the calcium carbide has therefore combined with the hydrogen of the decomposed water to form a new compound of a gaseous nature and extremely rich in carbon.

In its commercial application acetylene can be produced either directly from the calcium carbide by decomposition with water, or it may be evolved from the liquefied gas contained in suitable receivers.

Methods employed in producing the gas.

When manufactured directly from the carbide, two methods can be employed; in one, small quantities of water are allowed to flow upon the carbide and the resulting gas is conducted to an ordinary gasometer, from which it can be drawn for use; this method is more or less intermittent. The other method dispenses with a gasometer and permits the continuous generation of either large or small quantities of the gas, and this is accomplished by partially submerging in water a vessel, open at the bottom and containing carbide suspended on a screen in the upper part of the vessel, the generated gas being withdrawn from above the carbide. As long as gas is being used the water remains more or less in contact with the carbide; as soon however as the withdrawal of gas diminishes or entirely ceases, the pressure of the generated gas forces the water from the carbide into the lower chamber of the vessel, thereby preventing a further generation of the gas. The apparatus is automatic and extremely regular in its operation.

In the employment of either of the above methods the only by-product obtained is slaked lime, the amount of gas produced being the same, namely, 5½ cubic feet for each pound of calcium carbide used.

The liquefied gas is manufactured commercially by decomposing the carbide of calcium with water in a closed vessel and conducting the gas generated under pressure to a condenser, where it liquefies and is then drawn off in tanks ready for distribution.[8] The liquefied gas exhibited this evening has been produced in this manner.

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[8] A full description of this process and of the apparatus required therefore is contained in U. S. Patent No. 535,944, March 19, 1895.

Before entering upon the use of acetylene as an illuminant, we desire to call your attention to the fact that its rapid and extraordinary development in this direction is largely due to the individual efforts of Mr. E. N. Dickerson of New York city, who, endowed with a special knowledge of the subject, has labored unceasingly to bring about the successful result which you will see this evening.

COMPARATIVE VALUE OF ACETYLENE.

Acetylene as an illuminant compared with coal or water gas.

As an illuminant, acetylene surpasses in lighting power and economy all other illuminants known; when burned at the rate of five cubic feet per hour it produces a light equal to 250 candles, whereas the best illuminating gas made from coal, or water gas, rarely exceeds twenty-two candles for each five cubic feet burned per hour. Your Philadelphia city gas is rated at from nineteen to twenty candles. Acetylene gas will therefore produce twelve and one-half times more light if the same quantity be consumed, or 1,000 cubic feet of acetylene gas will give you the equivalent in lighting power of 12,500 cubic feet of your city gas; it has therefore twelve and one-half times the value. To illustrate more fully the difference, we will first pass your city gas to the tube attached to this stand, and ignite the gas as it issues from the burners; we then conduct acetylene gas to a similar row of burners, and light these; the contrast, as you will perceive, is almost marvellous.

Testing the gaseous and liquefied forms of acetylene.

The acetylene consumed in these burners has been generated in the apparatus before you in the following manner: Upon the carbide contained in this closed jar (Fig. 9) water is poured in small quantities through the glass funnel communicating with the interior of the jar. The acetylene gas generated passes through this tube to the inside of the gasometer, thereby lifting the holder to the position which it now occupies, and the gas can then be conducted from the holder to the burners by means of this rubber tube. As the gas is being consumed and the holder lowers, the supply is rapidly renewed by pouring an additional amount of water through the funnel upon the carbide contained in the closed jar. We will also light the gas produced from liquefied acetylene contained in this small tank (Fig. 10), and, as you observe, it burns with the same brilliancy and lighting power as the gas produced directly from the carbide.

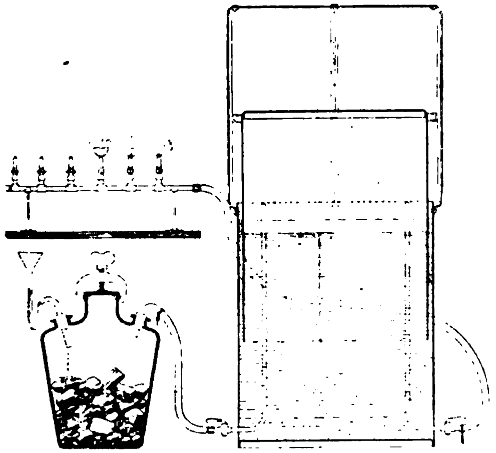

Fig. 9. Apparatus for the manufacture of acetylene from calcium carbide.

The liquefied gas contained in the small tank weighs just two pounds, and is capable of generating twenty-nine cubic feet of acetylene gas, which is at the rate of fourteen and one-half cubic feet per pound. The gas produced by the vaporization of the liquid at a pressure, as the gauge now indicates, of forty atmospheres, passes from the tank to a reducing valve upon which the tank stands, whereby its pressure is reduced to that of a two-inch water column, as indicated on this U water gauge, and it is under this pressure that we are supplying the gas to the burners attached to the arm above. Each of the burners supplied with acetylene gas will consume, at the pressure indicated, $1\frac{2}{10}$ cubic feet per hour; each therefore emits a light equal to sixty candle-power; the total candle-power of the six burners in use is therefore 360, and the amount of gas consumed each hour $7\frac{2}{10}$ cubic feet. To obtain this result with city gas would require the consumption of at least ninety cubic feet per hour.

A ratio of 1 to 12½.

The amount of oxygen withdrawn from the atmosphere of this room by the acetylene for the same amount of light is but one-sixth of that required for your city gas; the products of combustion are therefore reduced in proportion and the air of the room is not vitiated to the same extent.

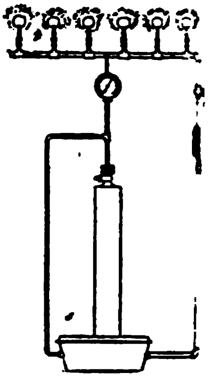

Fig. 10. Flame of liquefied acetylene.

Temperature of the flame.

From the appearance of the acetylene flame it would seem as though its temperature was exceedingly high, but recent determinations have shown that the temperature of the flame does not exceed 900° C, whereas the temperature of the ordinary illuminating gas exceeds 1,400° C. For an equal amount of light the heat developed by the combustion of acetylene gas but slightly exceeds that of the incandescent electric lamp.

An ideal illuminating gas.

We have before us to night therefore an ideal illuminating gas; its presence in a room can readily be detected by its penetrating odor: it emits more light with less heat than any other illuminating compound; it consumes less oxygen, and it can be commercially produced at less cost for an equal amount of light. Furthermore, it is capable of being stored either as a solid, in the form of carbide, or as a gas, or as a liquid; and these qualities alone are of exceptional value in its commercial application.

Utilities of acetylene,

As a solid, in the form of carbide, waste water-power throughout the world can be utilized for its manufacture, and it can be shipped long distances without material deterioration. As a gas it can be generated from carbide and applied as such; and in the form of a liquid it can be applied to all purposes of isolated lighting, such as railroad and street cars, carriages, bicycles, steamships, sailing vessels, street lighting (by placing a small tank in each lamp-post (see Fig. 2), house lighting (in both city and country), buoys, lighthouses, lanterns, and to the enriching of ordinary illuminating gas in dwellings. Its application to this latter purpose will permit the gas companies to produce a low-priced gas for heating purposes, which can then readily be enriched in each house with acetylene gas generated from a tank of the liquefied gas. To show the value of acetylene gas if applied to the lighting of your city, we will make a comparison which may surprise you. The amount of gas produced by your city works will approximate 4,000,000,000 cubic feet per

for light,

year, of say twenty candle-power. By the use of acetylene gas the amount of gas required would be reduced in the proportion of 1 to 12.5; or, 4,000,000,000 cubic feet of city gas could be replaced by 320,000,000 cubic feet acetylene gas, representing a saving of 3,680,000,000 cubic feet of gas annually.

fuel and heat.

In addition to its value as an illuminant, acetylene gas can be used commercially for power and heating purposes; and in the form of a liquefied gas it will be invaluable for such use. Its application in this direction is however such an extensive one that we are compelled to make it the subject matter of another paper. In conclusion, we desire to thank you all for your kind attention, and especially the officers and members of the Franklin Institute for the interest they have manifested in our work.[9]

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[9] Regarding the cost of calcium carbide Dr. Francis Wyatt makes the following statement in the Engineering and Mining Journal of December 15, 1894: "As the actual result of its recent practice, the Willson Aluminium Company has found that it can produce one short ton of calcium carbide from a mixture of 1,200 lb. of fine coal dust and 2,000 lb. of burnt lime, and at an expenditure of about 180 electrical horsepower per hour for 12 hours. These figures are not very far from those required by theory, and they agree very closely with those given by H. Moissan, who has also produced the carbide in an electrical furnace of his own invention. It would therefore seem safe to formulate the approximate cost of production somewhat as follows for both the carbide and the acetylene:

1,200 lb. coal dust, say	$2.50
2,000 lb. powdered burnt lime	4 00
180 e. h. p. from water at say 50c. per hour for 12 hours	6.00
Labor, etc	2.50
Cost per 2,000 lb. CaC_2, say	$15.00
Cost per 2,000 lb. C_2H_2, say	37.00

These figures would hold good not only for the present works in North Carolina, but at any other place where very cheap water power and equally cheap coal, lime and labor are procurable and accessible. . . If to the estimated cost already given for the calcium carbide there be added say $15 per ton for freight, incidentals and profit, the material for producing such a gas could be obtained at nearly all points for 30 cents per 1,000 cu. ft, ready for burning, and the convenience with which the calcium carbide can be packed and freighted, combined with the easy preparation of the gas itself in great or small quantities, at any time, should enable it, if not to be adopted for the common supply of large cities, to supply the requirements of country hotels and dwelling houses and of railway cars."

The Scientific American of March 23rd, 1895, says: "No recent chemical discovery has excited more interest than the direct production of acetylene. The calcium carbide process may properly be termed direct, for in it the carbon is first united to calcium and secondly to hydrogen, the calcium being supplied by lime and the hydrogen by water. We have given a number of papers on the subject, and the new process is now being presented in various exhibits, lectures and papers to the public. One private residence in the city has a small acetylene plant with which the house can be illuminated or which can be used to enrich the ordinary gas. If the calcium carbide can be produced commercially—and its promoters state most positively that it can be so produced—it will have a great effect upon the production of artificial light.

"Political economists, who have devoted some thought to the influence of modern scientific progress upon the condition of the world, recognize in the modern development of artificial illumination one of the most powerful instruments for the civilization of mankind. In old times the dark streets of cities were dangerous, because they were haunted by robbers who only lacked subjects because the people were afraid to go abroad after dark. When Argand invented his cylindrical lamp burner with central draught, he made one of the great steps forward in artificial lighting. The invention of plaited candle wicks, chemically treated, which as the candle burned would bend over and burn away, was considered a great discovery and achievement in its day, as doing away with snuffers. Then gas was introduced and proved to be the greatest civilizing agent for cities. When the streets were adequately lighted, crime at once diminished.

"In recent years the electric arc light has proved the best street illuminant, but gas or the incandescent electric light remains the favorite indoor illuminant. In the co-development of gas and electricity some interesting cycles or transformations of energies have resulted or have been worked out. Gas is primarily made for the purpose of giving light. When burned in the explosion gas engine it gives, from the physicist's standpoint, a far more economical result than is attainable with the steam engine. In the commercial sense the economy, owing to the high cost of gas, disappears.

"The gas engine burns some twenty feet of gas per horsepower hour, which gas represents an illuminating power of sixty to one hundred or more candles. For the production of such gas four pounds of bituminous coal suffice, which give also as side products a material amount of coke and a quantity of coal tar. If a gas engine drives a dynamo, we may get from it in incandescent lights as much or more candle power than from the original gas burned as such, while if we use arc lamps the production would be vastly increased. In the new acetylene process a similar but more complicated cycle exists. Power is expended in producing an electric current. The current is led to an electric furnace, where it heats to an almost immeasurably high temperature a mixture of lime and carbon. The lime is reduced and gives calcium carbide. This substance is treated with water and every pound evolves five cubic feet of acetylene, enough to give 250 to 300 candle power of light for one hour.

"Thus if we know how much horsepower is expended per hour in producing a definite yield of the calcium carbide, we can compare the economy of the different cycles. As a matter of figures, it is enough to say that they come out about the same. But the new product effects other results. It diminishes the minimum size of gas holder required for the usual exigencies of gas supply. A one-foot burner gives perhaps forty candle power, or as much as ten feet of ordinary gas would give. Hence a gas holder of one-tenth the ordinary size could be used. The new gas is made without heat, and without any dangerous agent such as gasoline. Finally, when the gas is made it is a permanent one. The utter simplicity of the apparatus and process is also striking.

"One of the curiosities of the carbide is that it will not burn. It can be drawn out white hot from the electric furnace and cast in moulds. A piece can be held in a Bunsen burner without the least effect. But if a drop of water is put upon the stony substance it effervesces, and the gas can be lighted and will burn like a piece of wood for a few seconds, until the water is exhausted. Then it goes out.

"Merely as a matter of scientific interest it is to be hoped that the commercial production will soon be accomplished. The merciless judgment of the balance sheet has wrecked many a most ingenious scientific triumph. It is to be hoped that acetylene will fare better."

SECTION V.

DIAMOND DRILL EXPLORATION.

Purchase of drills for exploring purposes authorized by the Legislature.

In the session of 1894 the Legislature of Ontario made an appropriation for the purchase of two diamond drills, to be used under the direction of the Bureau of Mines for exploring mineral properties on public or private lands. The section of the Act authorizing the purchase provides as follows :

The Commissioner of Crown Lands may, out of the moneys voted for that purpose, purchase not more than two diamond drills to be used in exploratory drilling of ores or minerals in the province, under rules and regulations to be made by the Lieutenant-Governor in Council. The regulations shall, amongst other things, provide:

1. For the control and working of the drills under the direction of a person or persons employed for the purpose by the Bureau of Mines.
2. As to the payment of freight charges where the drills are used upon mines or lands other than those owned by the Crown ;
3. As to the applications for the use of the drills and the method of dealing therewith ;
4. As to the charges for the use of the drills and for damages thereto, or wear or tear connected therewith, and otherwise as to the Lieutenant-Governor in Council shall seem meet.[1]

Proposals invited from the manufacturers of drills, and

As soon as the appropriation was voted, correspondence was opened with the manufacturers of diamond drills in Canada, the United States and England, inviting proposals for the supply of drills of the required capacity. Practical men were also consulted as to the best make of machine for the proposed work ; but, as might have been expected, their opinions were as varied as the drills with which their own experience had been gained.

W. H. Merritt and the Director of the Bureau appointed to deal with them.

Having received the proposals of manufacturers the Commissioner of Crown Lands called in the service of Mr. Wm. Hamilton Merritt as an expert and instructed him to act with the Director of the Bureau in the selection of one or two drills as authorized by the Legislature, and the following Report was the result of their joint enquiries:

REPORT ON PROPOSALS OF MANUFACTURERS.

TORONTO, July 25, 1894.

HON. A. S. HARDY, Com'r. of Crown Lands :

Report to the Commissioner of Crown Lands.

SIR,—The undersigned have the honor to report that, in accordance with your instructions, they have examined and compared the several proposals made to supply the Bureau of Mines with diamond drills for use in exploring mineral properties, as authorized by the 15th section of the Act of last session of the Legislature relating to Mines and Mining Lands.

In considering the character of work to be done, and the hard nature of the rocks likely to be encountered by diamond drills in this province, we concluded that it would be desirable to employ machines with capacity to bore a depth of not less than 1,000 feet, and therefore the proposals for machines of less capacity were put aside as unsuited to the work in view.

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[1] An Act relating to Mines and Mining Lands, 57 Vic. c. 16, s. 15.

Abstracts of proposals.

Comparison of the several proposals for drills of about 1,000 feet capacity was shown by the following abstracts, ordinary equipment being as nearly as may be the same with each drill:

1. The Jenckes Machine Co. f. o. b., Sherbrooke, Que. Drill to bore 1,000 feet, and equipment of diamond bit, two blank bits, core lifter, core barrel, 200 feet drill rods, steam pump, water joint and hose, safety clamp, hoisting swivel, and set of tools to operate machine and keep bits in order	$2,600	
Add for horizontal boiler on wheels	750	$3,350
NOTE.—A revised proposal from this company, received to-day, quotes figures in detail as follows: For drill, $1,500; equipment nearly the same as above, $797.75; and unmounted 12 h.p. boiler, $320, making a total of $2,617.75.		
2. Ingersoll Rock Drill Co. of Montreal, f. o. b Toronto. Drill to bore 1,200 feet, and equipment of diamond bit. two blank bits, bit holder, core lifter, core barrel, fishing tap, water joint and hose, 200 feet drill rods, safety clamp, hoisting sheave, pump, set of tools and portable boiler on wheels		$3,400
3. M. C. Bullock Manufacturing Co., f. o. b. Chicago. Drill to bore 1,000 feet, and equipment of diamond bit, two blank bits, bit holder, core lifter, core barrel, fishing tap, water joint and hose, 200 feet drill rods, safety clamp, hoisting sheave, 75 feet steel wire rope, and set of tools	$2,500	
Add for 10 h. p. boiler on wheels and steam pump	540	$3,040
4. Sullivan Machinery Co., f. o. b. Chicago. Drill to bore 1,000 feet, and equipment of two blank bits, core lifter, core barrel, water horse with connection, 75 feet wire rope, 200 feet drill rods, sheave for hoisting rods, safety clamp and set of tools	$1,700	
Add for diamond bit	272	
15 h. p. boiler on wheels and pump	444	$2,416
5. Burton, Jones & Co. of Liverpool, in bond Toronto. Drill to bore 1,000 feet with necessary pipes, tools and accessories, and 200 carats of diamonds (exclusive of boiler)		$5,910

The Bullock drill is manufactured at Chicago, and the Sullivan Machinery Company has its head office there also, although the works are at Claremont in Sullivan county, New Hampshire; but the interruption of travel due to the railway strike made it inexpedient to visit Chicago at the time of receiving your instructions. It was therefore decided to visit the works of the companies at Montreal and Sherbrooke in Quebec, and those of the Sullivan Company in New Hampshire, these being within easy reach of each other.

Ingersoll Rock Drill Company of Montreal.

At the office of the Ingersoll Rock Drill Co. in Montreal we learned that this company does not itself manufacture diamond drills, but merely acts as agent for the Bullock Company of Chicago, and since direct proposals have been received from the latter company it was not thought advisable to treat with an agent.

Jenckes Machine Company of Sherbrooke.

At Sherbrooke we visited the office and works of the Jenckes Machine Company and were afforded an opportunity of examining a drill made by that company under the patent of the American Diamond Rock-boring Company of New York. It is a No. 3 prospecting drill, and is the first and hitherto the only diamond drill manufactured in Canada. Its weight is 1,800 lb., the bit is two inches in diameter and it takes out a core of $1\frac{3}{8}$ inches. The machine was operated for us, but as it was not placed on a proper foundation and as the bit had not been set with diamonds, no drilling could be done. The running of the machine however seemed to demonstrate that this company is able to supply drills of good quality. The No. 3 drill is warranted to bore a depth of 1,000 feet.

Sullivan Machinery Company of Claremont, N.H.

At Claremont in New Hampshire the Sullivan Machinery Company manufactures diamond drills, as well as channelling machines for quarrying and coal mining; but the head office for sales is at Chicago. The works occupy a frontage of about 500 feet, and are commodious and well equipped. We were shown drills of all sizes made by the Company in various stages of construction, and were able to examine their parts in detail. We observed that the castings were of good quality and finish, and that facilities for supplying exact duplicates of the drills as well as of their several parts were ample. In the store-room of the works large lots of all the parts of a drill are kept in stock, so that in case of the breaking or wearing out of any part the loss could be promptly supplied.

A drill of the O class, set upon a substantial frame of hardwood and having all connections made for steam and water, was operated for us on a block of crystalline limestone. A careful examination of the machine showed that its various parts were of good material and well fitted together. The running was smooth, and the working of the hydraulic feed and the drill was eminently satisfactory. The double engines, hoisting gear and drilling apparatus are very compact and appear to be strong and durable.

The Bullock and Burton, Jones & Co. proposals.

With reference to the proposals of the Bullock Company and of Burton, Jones & Co., the prices are so much higher than the quotation of the Sullivan Company for machines of the same capacity that we do not consider it necessary at present to make further enquiries regarding them. An improvement recently adopted by the Bullock Co., whereby cores may be extracted without lifting the drill rods, appears to be deserving of investigation, but we understand that hitherto it has only been applied to drills of the largest class and for very deep borings.

The need of extra equipment and duplicate parts.

In the abstracts of proposals given above you will observe that they embrace a regular outfit with the drills, including 200 feet of drill rods, a diamond bit, and other necessary articles of equipment. But where drilling operations are carried on at a distance from the sources of supply it is important that an extra equipment should be provided, so that in case any part is broken or worn out it may be replaced out of stock and work resumed without loss of time. Extra supplies of parts most liable to wear or break, as well as of casing pipe and drill rods, are therefore a necessity for the economic working of the drill.

Three of the companies making proposals suggest certain articles of extra equipment for work in outlying localities, which when added to the proposals with regular equipment (and embracing as nearly as may be the same items) make totals as follows:

The Jenckes Machine Co. No. 3 drill	$4,274 38
M. C. Bullock Manufacturing Co. Chief drill	3,844 00
Sullivan Machinery Co. H drill	3,322 65

The advantage therefore as regards price is clearly in favor of the Sullivan drill, and if choice was confined to those three proposals we should not hesitate to recommend acceptance of the one made by the Sullivan Company.

The Sullivan Company's C drill.

We have however examined another proposal made by the Sullivan Company under date of July 6th for a drill of the C class, and having seen the machine in operation and compared it with the machine of the H class manufactured by the same company, we think it possesses merits which entitle it to first choice. It is a stronger machine, having a capacity to bore 1,200 to 1,500 feet, while the size of the core is the same as that of the H drill, one and three-sixteenths inches diameter; from which we conclude that it will do its work faster and with less strain, without practically any additional cost for operating. The greater depth to which it will take out a core is also an important point; for although it will rarely be necessary to bore more than a thousand feet, deeper drilling may sometimes be called for, especially on fissure veins and on ore bodies of nickel, copper and iron.

The price of the C drill is $700 more than that of the H, and its weight is more by 240 lb., but these differences we believe will be more than compensated by its greater efficiency and longer life.

You will notice that the extra equipment in the proposal for the C drill is much more complete than for the H, although the regular equipment is the same for both. We consider it advisable however to procure an ample supply of equipment, and of duplicate parts of the drill and outfit most liable to wear and break, since delay occasioned by waiting until these are procured from the factory would be annoying and expensive. It is only a matter of keeping in stock articles which are sure to be required sooner or later. We suggest the addition of a long reamer and a recovering tap to the list of articles in extra equipment, at prices as quoted to us of $20 and $15 respectively.

Boiler and steam pump.

From enquiries made here we are of opinion that the boiler and steam pump might be procured from Canadian manufacturers at prices which would effect a saving of not less than $200. The rate of duty on boilers under the new tariff is 27½ per cent. and on pumps 30 per cent., and under the customs regulations the motive power used to operate diamond drills is subject to duty.

Diamonds.

As regards diamonds, these will doubtless constitute the most expensive part of the equipment and maintenance of a drill. The present selling price in Canada and the United States is about $17 per carat, and under the Customs regulations of both countries they are free. In Great Britain the latest quotation is only 42 shillings stg. or about $10 per carat, but prices vary more or less according to supply and demand, or probably as the combines which control black diamond mines are able to regulate the market. During the last fifteen years prices have ranged from $3 to $22 per carat in the United States, but we have not been able to ascertain why there should be so great a disparity in prices as appears to be the case at present in Great Britain and the United States. It is advisable that enquiry be made from dealers in diamonds to ascertain the terms on which supplies may be obtained as they are required.

Recommendation to purchase

We observe that by the 15th section of the Act relating to Mines and Mining authority has been given by the Legislature for the purchase of two diamond drills. In view however of the lateness of the season, and the desirableness of proceeding cautiously in the selection of these machines, we would advise that only one drill be purchased out of the appropriation of this year. This will afford an opportunity of testing the suitability of the make and class selected for exploration work, as well as of ascertaining the demand by owners of mining lands for the employment of diamond drills.

one Sullivan drill.

As a result of our enquiries, and in view of the circumstances here set forth, we recommend the purchase of a Sullivan C drill with the full extra equipment as listed in the manufacturers' proposal of July 6th, with the addition of one improved reamer and one recovering tap; saving however the items of boiler and steam pump, which may be procured at the same or lower prices from Canadian manufacturers.

In conversation with the officers of the Sullivan Company it was stated to us that the Company is prepared to give a guarantee for the satisfactory working of their machine for a reasonable time. We advise that such guarantee be required.

Respectfully submitted,

(Signed) Wm. Hamilton Merritt,
Archibald Blue.

Sullivan C drill as per proposal of 6th July, with long reamer and recovering tap added	$4,339 50	
Deduct for boiler and steam pump	564 00	
	$3,775 50	
Add for boiler and steam pump, to be purchased in Canada, say	$480 00	
		$4,255 50

Cost of drill, equipment,

The report was approved by the Commissioner, and on 8th August a C drill was ordered from the Sullivan Machinery Company, to cost (less discount for cash), including two sets of diamonds and extra equipment, $3,611.77.

boiler and pump.

A boiler of 15 h. p. capacity, mounted on wheels and with fittings complete, was purchased from the Waterous Engine Works Company of Brantford for $375 f.o.b. Toronto; and a duplex pump, 6x3x7 inches, warranted to pump against a maximum pressure of 200 lb. to the square inch, from the Northey Manufacturing Company of Toronto for $140. Tenders were invited from manufacturers for both boiler and pump.

The drill was held by the Customs authorities in Toronto for six weeks, pending a decision by the Controller of Customs on the dutiable rates to be charged upon drill and outfit—although diamond drills are free under the Tariff Act. Under the Controller's ruling the charge for duty was $350.41, which was paid subject to revision. This with freight and brokerage made the total cost of the drill laid down in Toronto $3,991.75; but during the present year the Customs Department has remitted $230.90 on overcharge of duty, thus leaving the net cost $3,760.85.

RULES AND REGULATIONS.

The following Rules and Regulations for the control and working of diamond drills were approved by his honor the Lieutenant-Governor on 15th September, 1894, and subsequently ratified by the Legislature:

Rules and Regulations for the control and working of diamond drills.

1. The Bureau of Mines may employ diamond drills to explore public and private lands in the province for ores or minerals subject to the following Rules and Regulations, made under authority of The Mines Act 1892, and the amending Act of 1894:

2. The Commissioner of Crown Lands may request a skilled and competent person to examine any locality or territory of the public lands of the province, and upon receiving a report of a reasonable prospect of ores or minerals being found thereon he may require an exploration of the lands to be made with a diamond drill and may deal with them as provided in the third clause of section 12 of The Mines Act 1892.

3. The Commissioner of Crown Lands may grant the use of a drill to explore mines or mineral lands in the province owned or leased by any corporation, company, syndicate, firm, person or persons when application is made therefor in writing to the Director of the Bureau of Mines, subject to the following terms and conditions, viz.:

> The applicant or applicants to give a bond in the form of schedule A hereunder, or to the like effect, with sufficient sureties, or other security to the satisfaction of the Commissioner, for payment to the Treasurer of the Province at Toronto of costs and charges for—
>
> (1) Carrying the drill and all necessary plant to the mine or location and setting the same in place for running under proper cover;
>
> (2) Working the drill, including superintendence and labor, fuel and water;
>
> (3) Loss or breakage of bits, core lifters and core shells;
>
> (4) Wear or loss of diamonds, to be ascertained by weight and computed at twenty-five dollars per carat;
>
> (5) Other repairs of breakages and wear and tear of machinery, such sum per month as shall be estimated and certified by the mechanical manager, subject to appeal to the Director of the Bureau of Mines;
>
> (6) Together with an additional charge of fifty dollars per month for use of the drill from the date of report to the Commissioner that the mine or land has been shown through the use of the drill to be a valuable mineral property, where work is continued thereafter.
>
> All such costs and charges firstly above mentioned to be paid within one month from the date of putting the drill in place ready for operation, and all other costs and charges at the end of each and every month thereafter during the continuance of the work.[2]

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[2] SCHEDULE A.—FORM OF BOND.

Know all men by these presents that we of the of in the of , , of the of in the of , and of the of in the of , are respectively held and firmly bound to Our Sovereign Lady the Queen, Her Heirs and Successors, in the several sums following, that is to say: the said in the sum of dollars, the said in the sum of dollars, and the said in the sum of dollars, lawful money of Canada, to be paid to Our Sovereign Lady the Queen, Her Heirs and Successors, for which payments well and truly to be made we bind ourselves severally and respectively and not each for the other, and our

Rules and Regulations.

But to encourage the exploration of mines and mineral lands and to demonstrate the utility of diamond drills in such work, it is provided that forty per cent. of the aggregate of costs and charges above enumerated (except as to the charge mentioned above in number six) shall be borne by the Bureau of Mines in 1894, thirty-five per cent. thereof in 1895, thirty per cent. thereof in 1896, and twenty-five per cent. thereof each year thereafter until the end of the year 1900. Nevertheless no part of such costs and charges shall be borne or assumed by the Bureau of Mines after a report has been made to the Commissioner by the Director and Geologist and Mineralogist of the Bureau, based upon examination of the cores of the drill and other satisfactory evidence, showing that the mine or mineral land under exploration has been shown by the use of the drill to be a valuable mineral property.

4. Applications for use of drills will be dealt with in the order of the date of receipt; but satisfactory evidence may be required to show that there is a reasonable prospect of valuable ore or mineral being found upon a property before the granting of a drill to explore it is sanctioned by the Commissioner of Crown Lands. The Commissioner may also in writing give precedence to a later application where in the case of an earlier one there is neglect or delay in completing the preliminary arrangements, or (to prevent loss of time and extra cost of transportation) where two or more applications are from the same or a contiguous locality, but in such case he shall state in writing the reasons for giving such precedence. The Lieutenant-Governor in Council may also give precedence to an application to explore a recent and promising discovery of ore or mineral where it appears to be in the public interest that a speedy test should be made, or where substantial exploratory or mining work is being carried on, or for such other special reasons as may appear to best serve and promote the interests of mining in this province, and in such case the Order in Council shall set forth the reasons for giving such precedence.

5. The Commisioner of Crown-Lands may upon the report of the Director of the Bureau of Mines suspend or terminate the working of a drill at any time, and the corporation, company, syndicate, firm, person or persons for whose benefit such drill was being used shall not have any claim to compensation on account of such suspension or termination.

6. A competent mechanical manager appointed by the Lieutenant-Governor upon such terms as to a trial and otherwise as may be deemed desirable shall have the control and working of each drill, subject to the instructions of the Director of the Bureau of Mines, and shall be responsible for the efficient

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respective heirs, executors and administrators firmly by these presents. Sealed with our seals and dated this day of , 18 .

Whereas by section 15 of an Act passed by the Legislative Assembly of the Province of Ontario in the fifty-seventh year of Her Majesty's reign, entitled "An Act relating to Mines and Mining Lands," it was provided that the Commissioner of Crown Lands might purchase not more than two diamond drills to be used in exploratory drilling of ores or minerals in the Province under Rules and Regulations to be made by the Lieutenant Governor in Council, and whereas the above-named has applied to the said Commissioner for the use of a diamond drill purchased under authority of the said section to explore for ores or minerals upon the following lands, that is to say:
of which lands the said is (*owner or lessee*), and the said Commissioner has agreed to allow the use of the said drill to the said for the purposes aforesaid under and subject to the Rules and Regulations made and approved by the Lieutenant-Governor in Council dated the fifteenth day of September, 1894.

Now the condition of this obligation is such that if the said shall well and truly pay to the Treasurer of the Province of Ontario all the costs and charges of and incidental to the use of the said drill upon the said lands to the amounts and at the times and place and in the manner prescribed by the said Rules and Regulations, and shall in all respects observe and comply with the terms of the said Rules and Regulations, then this obligation to be void, otherwise to be and remain in full force and virtue.

Signed, sealed and delivered
in presence of

Rules and Regulations.

and economic working of the drill, and for the care and safe keeping of the drill, boiler, pump, equipment and stores. He shall also be required—

(1) To have oversight of the boiler, conduct the running of the drill, set or refit the diamonds when necessary, keep an accurate daily record of the progress of borings, and preserve the cores in boxes supplied for the purpose in such a way as to show a complete and continuous section of the rocks, formations, veins or mineral deposits so explored;

(2) To superintend transportation of the plant and its removal from one site to another, to set it up in a proper manner where borings are required to be made, and to erect a sufficient cover for the drill and boiler so that operations may be carried on in any weather;

(3) To act upon the advice of the person authorized to mark the site and indicate the course of each boring and the depth to which it shall be continued, unless otherwise instructed by the Director of the Bureau of Mines;

(4) To keep an accurate and detailed account of all expenses of transportation, labor, repairs, fuel, supplies, etc., required in connection with the employment of the drill, and to make a report thereof monthly to the Director of the Bureau, and to transmit therewith all bills and vouchers for the same;

(5) To make a weekly report of progress to the Director of the Bureau while in the field, and to report forthwith any stoppage of operations due to accident or other cause;

(6) To make a detailed report to the Director of the Bureau of the operations of each year.

7. The mechanical manager shall not impart or reveal the knowledge or information acquired by him in exploring with the drill, nor exhibit the cores and cuttings of the drill, except to the Director of the Bureau of Mines, or to any person whom the Director may designate in writing, or to an authorized agent or representative of the corporation, company, syndicate, firm, person or persons for whom the property is being explored, and he shall dispose of the cores and cuttings of the drill only as he may be instructed by the Director.

8. The mechanical manager shall give a bond with sufficient sureties or other acceptable security in a sum of not less than one thousand dollars, for the faithful performance of his duties as mechanical manager and for the right care and use of the plant, equipment and stores placed in his charge.

9. The Commissioner of Crown Lands may when necessary employ a fireman to assist the mechanical manager in operating each drill at such rate of wages and allowance for expenses as may be agreed upon for the period of his employment in the field, reckoned from the day of going out to the day of returning, and the person so appointed shall in all matters appertaining to his duties be subject to the orders of the manager.

REPORT OF PROGRESS.

Exploring the Glendower iron mine in Frontenac county.

A number of applications were received for the use of the drill from persons and companies in various parts of the province, but following the provision of the Rules and Regulations the preference was given to the application of Mr. Joseph Bawden of Kingston. The drill was shipped to Bedford station, on the line of the Kingston and Pembroke railway, as soon as it was relieved from the customs, and it has been employed steadily since the beginning of November in exploring the iron ore deposit of the Glendower mine. This property is on the shore of Thirty Island lake in the township of Bedford, Frontenac county, about four miles from the Kingston and Pembroke railway. It had been worked for several years, beginning with 1873, a spur line was built to connect it with the railway, and it is stated that 12,000 tons of ore were taken out and shipped to the United States. A number of openings were made, and one shaft was sunk to a depth of about 200 feet, at which point the ore was found to carry too high a percentage of sulphur. The objects of exploration with the drill were (1) to prove the extent of the ore body, and (2) to ascertain whether ore of good quality was obtainable below the horizon at which sulphur was developed. Five prospects have been completed and a sixth is in progress. For No. 1 the machine was set about 75 feet south of the shaft, and the boring was made at an angle of 80° northward; but the plan of the old workings having been lost the drill ran into the drift at a depth of 182½ feet. Time, 9 days. For the second prospect the machine was set on the northwest side of the ore deposit, 150 feet from the shaft, and the boring made at an angle of 70° south. The depth reached was 702 feet; but as the angle of dip of the vein was nearly the same as or less than the angle of the boring, and in the same direction, the ore body was not struck. Time, 46½ days. For the third prospect the machine was set 150 feet southeast of the vein, and the boring made at an angle of 70° in a line west of north to a depth of 380 feet, cutting across the ore body. Time, 27½ days. The fourth prospect was bored from the same site of the drill, but at an angle of 78° in the same line as the third, to a depth of 400 feet. Time, 29 days. This prospect was completed on 21st March. The fifth prospect upon the same site was bored at an angle of 78° in a northwest line, and at the end of April had reached a depth of 450 feet. The total depth of the five borings to that date was 2,214½ feet, and the cost of the work, exclusive of diamonds and the wear and tear of machinery, was $1,634.28, or an average of 77⅓ cents per foot. Of this amount the Bureau of Mines assumes under the Rules and Regulations $607.93, leaving $1,026.35 to be charged to the owner of the property, or an average of 48½ cents per foot.[3] Operations were continued without interruption throughout the winter, although frequently the temperature was below the zero point, and the working time was ten hours per day.

Details of the borings.

Cost of the work, exclusive of diamonds and wear and tear of machinery.

What the borings have proved.

The mechanical manager reports that the borings have demonstrated the existence of a body of solid ore about 25 feet in thickness almost entirely free from sulphur, lying between bands of mixed ore. A full account of the

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[3] In the New York Engineering and Mining Journal of September 22 and 29, 1894, J. Park Channing gives the following details of actual cost per foot of boring nine holes at the bottom of a pit to an aggregate depth of 2,091 feet with a Sullivan S drill, on one of the iron ranges in Michigan.

Labor on drill	$0.606
Fireman	0.206
Fuel	0.182
Camp account	0.722
Repairs on drill, bits, core barrels, etc	0.126
Repairs on boiler and machinery and sundry supplies	0.097
Carbons	0.239
Superintendence	0.196
Total cost per foot	$2.374

The first four items of this cost per foot, together with the last item, are also included in the cost of working the Government drill at Glendower, and the comparison therefore stands as $1.91 to 77⅓ cents per foot. No information is given as to the character of the rock in Michigan. At Glendower it is crystalline limestone and granite, with bands of hornblende, and the formation in places being badly broken it was necessary to lift the rods often. In boring the second, third and fourth prospects, an aggregate depth of 1,664½ feet, the drill rods were lifted 285 times, being an average of one time for every 5.84 feet.

exploration of the Glendower mine with the diamond drill will be prepared for the next report of the Bureau.

Working of the drill.

The drill itself has given excellent satisfaction. No hitch or delay has occurred in the working of it, either through imperfect gearing, defective parts or breakages, and in every respect hitherto the representations of the manufacturers regarding it have been borne out by performance in the field.

SECTION VI.

NICKEL AND ITS USES.

Progress of nickel mining in Ontario as shown by the Trade Tables of export.

In the first Section of this Report particulars have been given of the progress of nickel mining in the province as shown by the annual returns made to the Bureau. Further information on the same subject is furnished by the Trade Tables of the Dominion, which give the quantity and value of nickel exports for the four fiscal years 1890-1 to 1893-4, inclusive. In these tables the quantity is the estimated contents of fine nickel in the matte and ore shipped from the country, and quantity and value are presumably computed from data furnished by the exporters when the necessary entries are made. The following table gives the exports for the four fiscal years, classified by countries :

Exports of the fiscal years 1890-1 to 1893-4.

Year.	Country.	Quantity. lb.	Value. $	Total quantity. lb.	Total value. $
1890-1	Great Britain	847,660	30,180	5,352,043	240,499
	United States	4,504,383	210,319		
1891 2	Great Britain.	2,700,124	151,122	15,233,028	617,639
	United States	12,532,904	466,517		
1892-3	Great Britain	516,000	27,600	8,924,000	427,557
	United States	8,174,000	388,257		
	Germany	234,000	11,700		
1893-4	Great Britain	1,025,904	113,457	8,411,276	808,799
	United States	7,385,372	695,342		
Totals		37,920,347	2,094,494	37,920,347	2,094,494

Statistics of doubtful accuracy.

The average value of nickel in the foregoing table for the fiscal year 1890-1 is 4½ cents per lb. ; in 1891-2 it is 4 cents per lb. ; in 1892-3 it is 4¾ cents per lb. ; in 1893-4 it is nearly 9⅔ cents per lb. ; while the average for the four years is 5½ cents per lb., although the market during this period was steadily falling. The returns made to the Bureau by the companies operating in the Sudbury district (which is the only nickel producing district in the Dominion) give averages widely different from these, as may be seen on referring to page 21 of this Report. There the values are computed at the selling price per unit of metal contents at Sudbury, and the average per lb. ranges in round numbers from 14 cents in 1892 to 12 cents in 1894—counting the years from 1st November to 31st October. In another respect too the returns made to the Bureau differ widely from those of the Trade Tables of the Dominion, the latter giving the total export of the four fiscal years from 1st July, 1890, to 30th June, 1894, at the equivalent of 18,960 tons of fine metal, or over 6 per cent. in the raw ore, and the former at 10,165 tons for the five years from 1st November, 1889, to 31st October, 1894, or about 3 per cent. in the raw ore. These discrepancies seem to be inexplicable on the assumption that the producers have supplied the data for computing the estimates both to the Customs Department and to the Bureau, and in the interest of the nickel industry itself it is desirable that the facts be ascertained. There can be no doubt, I think, that the values of the Trade Tables are erroneous, seeing that the average rate per pound in 1893-4 is more than double the rate of 1890-91, and that the market price of fine nickel had fallen in the interval by fully 30 per cent.[1]

The nickel industry of New Caledonia.

The only important rival of Ontario in the production of nickel is New Caledonia, in the Pacific ocean. The discovery there was made in 1863 by Garnier, who in exploring the island was struck by the special green color of the rocks, which he found to be due to coatings of veins and lumps of a hydrous silicate of nickel and magnesium. The nickel is found in serpentine, either at the contact of this rock with pockets of red clay, or near such a contact, but never in the clay itself.[2]

Mr. A. G. Charleton of England in a recent paper on the nickel industry of New Caledonia states that ore containing 7½ to 8½ per cent. nickel is worth at the port of shipment about $21 per ton, and ore with 9½ to 10½ about $25 per ton. The freight from Noumea to Havre is about $8 per ton of ore. "The principal mining companies," Mr. Charleton says, "are Le Societe Nickel and the Societe d' Exploitation des Mines de Nickel. The properties worked by the former company are all situated in this district, and in 1890 91 produced 32,000 to 33,000 tons of ore containing 7 per cent. nickel, whilst in 1892 and 1893 their output is stated to have been 40,000 tons. Besides these two companies there are several small ventures. Le Societé Nickel buys all the ore mined in New Caledonia, and owns some 60,000 hectares of mineral land on the island, but is only working 1,000, from which it is said to have cleared a net profit of more than 6.000,000 francs in one year, with a capital stock of 12,720,000 francs."

The same writer gives some account of nickel mining and treatment of nickel ore in Norway, but for the most part his information is ancient history. I am indebted to Mr. Gudbrand Henriksen of Ringerike for the following interesting particulars, which supply information on the state of the nickel industry of Norway at the present time :

The nickel industry of Norway.

"In the last five or six years," Mr. Henriksen writes, "the annual production from the mines has been 5,000 to 6,000 tons of nickel ore, with an average contents of about 100 tons nickel and 35 tons copper. Most of this has been delivered by the Evje and Ringerike mines.

"The ore is roasted in heaps and smelted to matte containing from 7 to 11 per cent. nickel. The matte is roasted in heaps and concentrated to second metal containing from 25 to 34 per cent. nickel. The second metal is reduced to a product containing 50 to 55 per cent. nickel and cobalt (about 2 per cent. cobalt), 15 to 20 per cent. copper, 6 to 11 per cent. iron and 18 to 22 per cent. sulphur, which is sold to the foreign refineries.

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[1] In the last issued Report of the Geological Survey (1890-91) statistics of quantity and value of nickel contents of ore, matte, etc., are given for the calendar years 1890 and 1891, values being computed at average market price. For 1890 the product was 1,435,742 lb. and value $933,232, and for 1891 the product was 4,626,627 lb. and value $2,775,976. For the latter year however the price paid for nickel in the matte is said to be 13 to 21 cents per pound, or an average of 17 cents, which is the proper basis of valuation.

[2] LeNeve Foster's Text Book of Ore and Stone Mining, pp. 60, 99.

"Ringerike's nickel works is situated 58 kilometers from Drammen, and is in railway communication with that port. Evje nickel works is 70 kilometers from the port of Christianssand, and a railway from Christianssand passing by the works will be ready in the autumn of 1896.

"For the smelting is used English and partly German coke. Both at Evje and Ringerike the machinery at the smelting works is worked by waterpower.

"The Norwegian deposits of nickeliferous pyrrhotite occur as contact formations in gabbro, of the petrographical species norite."

Mr. Charleton states that the cost of producing ore of 2 per cent. grade in Norway varies from $1.67 to $3.09, averaging $2.38. One kilogram of nickel in the ore therefore costs 10.71 to 14.28 cents,—the small quantity of copper contained in the ore being reckoned free. In a few mines operated on a large scale the cost may be as low as 7.14 to 9.52 cents.

Future of the nickel trade

affected by the drop in prices.

The future of the nickel trade is reported to be causing much interest in metallurgical circles. Since June of last year the price of the metal in England has fallen between £40 and £50 per long ton, and this heavy drop has had a serious effect on the industry. For the year ended June, 1894, the well known firm of H. H. Vivian & Co. of Swansea are said to have lost over £40,000, and the balance sheets of the great French company, Societe le Nickel, furnish an equally unsatisfactory record. The year showed, as compared with 1892-3, a deficiency of £41,760, there being £34,560 less profits and £7,200 more expenses. The profit from the sales has fallen from £80,000 to £56,000, and the interest on debentures has gone up £8,640. Out of the profit balance of £56,420 the directors propose to appropriate £26,800 on depreciation account—£6,800 to write off works in Europe, plant, machinery, etc., and £20,000 to be set aside to meet further depreciation on items where it may appear necessary to the Council. This permits of only £1,200 being carried forward to the current year.[3] The main cause of this falling of in the profits of European nickel refineries is the slump in prices, and this in a large degree is attributable to the adoption of better and cheaper processes in producing fine nickel—notably at the Orford Copper Company's works.

NICKEL STEEL ARMOR PLATE.

Demonstrations of the value of nickel steel for armor plate.

There is no reason to doubt that any decline is likely to occur in the use of the metal; the strong probability is that the requirements will continue to increase, as must be evident from a perusal of the statements as to its value in the papers of Mr. Sperry and Captain Jaques which follow. The early experiments made in the United States with nickel steel as armor plate not only remains unchallenged, but improvements in processes continue to demonstrate its utility for this purpose in a very remarkable degree. Why the officers of the British Admiralty have reached an adverse decision regarding its merits does not clearly appear from any reports which they have made themselves. A few of the later tests will illustrate how strongly the new armor has entrenched itself in the opinions of competent men who have given to it a fair trial.

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[3] Industries and Iron, March 22, 1895.

Test of Krupp plates.

In December of last year plates made at the Krupp works in Germany were tested at that company's proving grounds in the presence of representatives of the German Admiralty, when the results proved that nickel steel plates from 142 to 146 millimeters (5.59 to 5.75 inches) in thickness, were equal as regards resistance to any 240 millimeters (9.45 inches) plate previously manufactured at the Krupp works. No information however is given concerning the new process of treating the plate.[4]

Test of the Bethlehem Company's plate.

On 19th February of this year a 15-inch nickel steel Harveyized armor plate made by the Bethlehem Iron Company was officially tested with remarkably good results at the Bethlehem proving grounds. Two Carpenter 10-inch projectiles of 500 lb. each were fired against it at a range of 200 feet. The first charge used was 161 lb. of hexagonal powder, imparting a velocity of 1,539 feet per second, and this test was for cracking the plate. It utterly failed to do so, for the plate was penetrated only 2 inches and the chrome steel shot went to pieces, welding itself to the plate with about 3 inches projecting in the centre. The second shot was for penetration, and 241 lb. of powder were used, giving a velocity of 1,940 feet per second. Again the plate did not show the faintest sign of a crack; the projectile penetrated about 6 inches, was welded to the plate over a diameter of 18 inches, and the bulk of it was broken into minute fragments. The members of the Naval Board present declared the test one of the most signal triumphs of armor over gun and projectile ever witnessed there or abroad. Among the interested spectators was Captain Riazanine of the Russian Navy, stationed at Bethlehem to inspect the manufacture of armor plate for the Russian battle ships.[5]

Test of the Carnegie Company's plate.

A test for the acceptance of plate representing a group of 315 tons 18-inch Carnegie Harveyized armor for the battle ship Oregon was made at Indian Head on March 11th. The test plate was held in position against a 36-inch backing by 20 armor bolts of ordinary size. A 12-inch gun was used, and the line of fire for both shots was within one degree of perpendicular to the surface of the plate. The first shell fired was an 850 lb. armor piercing projectile with a charge of 250 lb. of brown powder, giving a velocity of 1,458 feet per second. The shell struck the plate half way between the top and the bottom and about 18 inches from the centre, the energy at impact being 11,000 foot tons. The shell broke up on the face of the plate, its head welding into the metal. It was estimated that the penetration did not exceed 5 inches. There were no cracks, but a slight front bulge was visible at the point of impact, and the plate scaled somewhat around the place where it had been struck. No bolts were disturbed. The shot for penetration, an 850 lb. armor piercing projectile, required a charge of 443 lb. of powder and velocity of 1,925 feet per second. This shell struck the plate about 3½ feet from the top. After penetrating 7 inches it broke up and rebounded, leaving its head welded into the face of the plate. The plate was cracked completely in two across its width. The appearance of the metal about the point of impact was similar to that of the first shell. An examination of the metal where the plate was cracked showed it to be remarkably tough. Its performance resulted in the acceptance of the group which it represents.[6]

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[4] Industries and Iron, December 28, 1894.

[5] Industries and Iron, March 8, 1895.

Prospect of further and larger uses.

The reports of these tests show that steady progress continues to be made in the production of nickel steel plate, and it cannot be assumed that the limit of possible attainment has yet been reached. No tests of all steel plate made elsewhere, whether surface hardened or not, have exhibited such powers of resistance to attack.[7] And where such demonstrations of efficiency have been given, the pertinence of the query with which Captain Jaques closes his paper will strike most people as eminently sensible.

The various other uses of nickel, some of which are referred to in the paper of Mr. Sperry, make it obvious that the demand for it will continue; and with the adoption of improved methods in separating the metal from its ore the tendency of prices is almost certain to be downward, the natural consequence of which must be its more general adoption for the purposes for which it is proven to be suitable. Nickel is yet a comparatively new metal, and it may be that much remains to be learned of its qualities and uses.

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[6] The Engineering and Mining Journal, March 23, 1895.

[7] Since this report was presented to the Legislature a report has been published of another trial of 18-inch Harveyized plate which has given the highest results hitherto attained. The test took place at Indian Head on May 1st, and the following particulars of it are given in Industries and Iron for 24th May: "The plate weighed 79,300 lb., was 16 feet 9½ inches long and 7 feet 5 inches wide, and was of tapering thickness, being 18 inches thick at the top and extending 4 feet down, where the taper to 8 inches thickness at the bottom began. The plate was attached to a backing of 36 inches of solid oak by 26 inch bolts. The first projectile was an 850 lb. 12-inch Holtzer shell, driven by 249.8 lb. of brown hexagonal powder, resulting in a velocity of 1,465 feet per second. The shell struck the plate with an energy of 12,662 foot tons. The plate was not cracked, but the nose of the projectile was pushed into the hardened metal about six inches. The second shot was fired with a projectile similar to the first one, propelled by 443.4 lb. of powder, giving a muzzle velocity of 1,926 feet per second, and the enormous striking energy of 21,885 foot tons. The penetration was 10 inches, as near as could be estimated. The head of the projectile as far as the explosive chamber was smashed on the plate, while a crack three-fourths of an inch wide was developed in the surface of the plate, extending from the top to the bottom. The plate was accepted by the Government, and then with the view of determining what its ultimate test might be under the most extreme conditions it was decided to attack it with the big 13-inch gun. Accordingly a 13-inch Carpenter shell weighing 1,100 lb., driven by 489 lb. of powder, specially adapted to this gun was discharged with a velocity of 1,810 feet per second. It had the enormous striking energy of 25,000 foot tons. While it was expected that the plate would be demolished, only a small crack 3 inches wide appeared, extending some distance from the top, and the shell after penetrating 10 inches was almost pulverized. The solid oak backing was split into kindling wood, while but one of the fastening bolts was damaged, and it is said that the other 25 would have held the plate in position on shipboard." A few weeks previously, as the result of tests with double forged plate, the U. S. Government adopted a rule which requires that armor plate for all future use shall undergo the double forging process. By this improved process 17-inch plates are reduced without reduction of weight to 14 inches after being submitted to furnace treatment, and 8-inch plates are reduced to 6 inches. This it is claimed by the New York Iron Age will be another important advance in armor manufacture, as the armor with the same weight will occupy less space as far as thickness is concerned. In a trial on 30th April of 8-inch armor plate from the Carnegie plant reforged to 6 inches, a 6-inch projectile propelled by a velocity of 2,100 feet per second on the first round was repelled by the impenetrable surface, making only what might be characterized as a mere dent, while the projectile itself went into pieces. The second round made a slight penetration, but did not go through the plate. For comparatively thin plates this result was regarded as very satisfactory; and the Ordnance officers, who are usually very conservative in accepting advances in methods of treatment and manipulation, are beginning to think that the reforging process will prove a very great advantage not only in toughening the plate by the resulting more compact condition of the grain, but will greatly lessen the bulk and consequently facilitate the propulsion of the mass of metal which constitutes the hull of the modern battle ship.

NICKEL AND NICKEL-STEEL.[8]

By Francis L. Sperry, Cleveland, Ohio.

Up to within a few years the consumption of nickel has been more directly dependent upon the available supply than that of any of the other useful metals.

Sources of the supply of nickel.

The Gap mine, in Lancaster county, Pennsylvania, has been for the last quarter of a century the only property in this country furnishing nickel in paying quantities. Its yearly output was about 300,000 pounds of metallic nickel, or nearly half the amount used annually in the United States. Foreign nickel from mines on the New Caledonia islands, in the South Pacific, found entrance into our markets as the production of the Gap mine fell off. The price of nickel was constantly maintained, and no special effort was made to extend its use. Over-production was cautiously guarded against, and all surplus metal was held by the banking-houses of the Rothschilds, who assumed the bonded indebtedness of the Société le Nickel. The opening of the Ontario nickel mines has however brought about a radical change; and nickel from the Sudbury district can be delivered in New York within four days, and in European markets within two weeks, as against two months consumed in transporting South Pacific ores. Former prices have been irretrievably smashed, and European trade-journals comment favorably on the influence which Canadian nickel has had in making lower prices and breaking the backbone of the "nickel trust."

Production and prices.

The quantity of nickel produced and the prices which it commanded may be briefly summarized as follows:

The total production of the world from 1840 to 1860 was about 100 to 250 tons yearly of metallic nickel; from 1860 to 1870, 600 to 700 tons yearly; from 1870 to 1889, about 1,500 tons yearly; in 1890, 2,000 tons; and a fair estimate for 1894 is about 5,000 tons. The metal sold for $2.25 per pound in 1860; in 1873 to 1875, for $6 to $7 per pound. From that time the price of nickel gradually declined, being $0.65 per pound in 1892, and less than $0.40 at the present time.[9] The exceedingly high prices in 1873 to 1875 were caused by the adoption of a nickel coinage by Germany and some other European nations, causing a sudden demand which exceeded the supply.[10]

PROPERTIES OF NICKEL AND ITS ALLOYS.

As compared with iron and copper.

Nickel has similar physical properties to those of iron and copper. It is less malleable and ductile than iron, and less malleable and more ductile than copper. It alloys with these metals in all proportions. It has nearly the same specfic gravity as copper, and is slightly heavier than iron. It melts at a temperature of about 2,900° to 3,200° Fahr. A small percentage of carbon in metallic nickel lowers its melting-point perceptibly. Nickel is harder than either iron or copper; is magnetic, but will not take a temper. It has a grayish-white color, takes a fine polish, and may be rolled easily into thin plates or drawn into wire. It is unappreciably affected by atmospheric action, or by salt water. Commercial nickel is from 98 to 99 per cent. pure. The impurities are iron, copper, silica, sulphur, arsenic, carbon, and (in some nickel) a kernel of unreduced oxide. It is not difficult to cast, and acts like some iron in being cold-short. Cast bars are likely to be porous or spongy, but after hammering or rolling, are compact and tough. A piece of pure nickel rolled plate (A) and an untreated cast bar of nickel (B) were submitted to physical test by the writer at the works of the Carbon Iron Co., Pittsburgh, Pa., with the following results:

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[8] A paper read at the Florida meeting of the American Institute of Mining Engineers, March, 1895, and republished with the author's sanction.

[9] This was the New York quotation, where the tariff is an element in fixing the price. In the free market of London quotations ranged from 15d. to 17½d. in March, or say 30 to 35c. per pound.

[10] J. H. L. Vogt, nikkel-forekomster og nikkel-produktion, Kristiania, 1891.

Cross-section.	Length between fillets.	Ultimate strength per sq. in.	Reduction of area.	Ultimate elongation.
in.	in.	lb.	p. c.	p. c.
A—3.11 by .045...	8	69,390	31.5	31.4
B—0.623.	2	30,985	6.5	6.5

The following table shows the properties of the metal:

Test of strength of malleable nickel.

Material.	Tensile strength.	Elongation.	Remarks.
	lb. per sq. in.	p. c.	
Casting	85,000	12	
Wrought nickel	96,000	14	Wrought from 2 by 4 inches to ½ inch square.
Wrought nickel, annealed.	95,000	23	Wrought from 2 by 4 inches to ½ inch square.
Rolled nickel............	78,000	10	Very hard, because not annealed after rolling; rolled from 2 to ⅛ inch.

These figures are an average of a number of tests. As there were flaws in several of the specimens, the results are lower than they otherwise would have been.

Nickel readily takes up carbon, and the porous nature of the metal is undoubtedly due to occluded gases. According to Dr. Wedding, nickel may take up as much as 9 per cent. of carbon, which may exist either as amorphous or as graphitic carbon, or in both conditions.[11] The affinity which nickel shows for carbon is manifested in a striking manner in the Mond process of refining nickel.

Magnesium as a purifying agent in nickel.

Dr. Fleitmann of Germany first discovered that the use of a small quantity of pure magnesium would free nickel from occluded gases and give a metal capable of being drawn or rolled perfectly free from blow-holes. Magnesium in nickel, like manganese in steel, acts as a purifying agent, and it improves the ductility and malleability of nickel to such an extent that the metal may be rolled into thin sheets 3 feet in width. Aluminium or manganese may be used equally as well as a purifying agent; but either, if used in excess, serves to make the nickel very much harder.

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[11] Stahl u. Eisen, No. 8, 1893.

The alloys of nickel.

Nickel will alloy with most of the useful metals, and generally adds the qualities of hardness, toughness and ductility. It is commonly alloyed with copper and zinc in making the composition known to the trade as German silver, white metal, British plate, packfong or Chinese metal, argentan, electrum and maillechort, the hardness and whiteness of this alloy depending upon the percentage of nickel it contains. Nickel coins current in Germany, Belgium, Italy, the United States and Latin American countries contain 25 per cent. of nickel and 75 of copper. German silver has a considerable use in electrical fixtures and appliances, having a very high specific resistance. The alloy known as "christofle" is composed of 50 parts nickel and 50 parts copper. As yet comparatively little use is made of this alloy in the United States; abroad, it is largely employed in the manufacture of coachmakers' and saddlers' supplies, as well as for surgical instruments.

Analyses of nickel-alloys of various countries do not show very great difference in the percentage of nickel.

Analyses of nickel alloys.

—	Copper.	Nickel.	Zinc.	Iron.	Cobalt.
Berlin Alloys.	p. c.	p. c.	p. c.	p. c.	p. c.
Richest	52.00	22.00	26.00	......	......
Medium	59.00	11.00	30.00	......	......
Poorest	63.00	6.00	31.00	......	.....
French Alloys.					
Tableware	50 00	18.70	31.30	......	......
"	50.00	20.00	30.00	......	......
Maillechort	65.40	16.80	13.40	3.40	......
Austrian Alloys.					
Tableware	50.00	25.00	25.00	......	......
"	55.60	22.20	22.20	......	......
"	60.00	20.00	20.00	......	......
Sheffield, England, Alloys.					
Silver white	55.20	20.70	24.10	......	......
Electrum	51.60	25.80	22.60	......	.....
Hard alloy[12]	45.70	31.30	20.00	......	......
English	60.00	18.80	17.80	......	3.40
" elastic	57.00	15.00	25.00	......	3.00
Chinese packfong	40.40	31.60	25.40	2.60	......
American Alloys.					
Alloy for castings	52.50	17.70	28.80	......	....
" " bearings	50.00	25.00	25.00	......	......
Bullet-shell	75.50	24.10	.....	0.40	.....
One cent coin	88.00	12.00	.....	......	...

		p c.
Vivian & Co., Swansea, copper-nickel alloy, ...	Si.	.303
	Fe.	.826
	Cu.	48.49
	Ni.	50.09
Société le Nickel, Paris, copper-nickel alloy, ...	Si.	.186
	S.	.089
	Cu.	48.740
	Ni.	49.26
	Fe.	.610
Wiggins & Co., Birmingham, England, copper-nickel alloy, ...	Si.	.136
	S.	.041
	Cu.	47.68
	Ni.	49.87
	Fe	1.228

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[12] Can be worked cold.

STEEL AND NICKEL STEEL.

Improvement in the quality of steel, and extended uses of it.

It will hardly be questioned that scientific research is directed most energetically at the present time upon the art of uniting elements in such proportions that they may be more serviceable than in their pure state. The limit of ultimate strength in the practical application of pure metals has about been reached. The practical introduction of steel into general use has made a new era in manufactures, and "steel is only modified iron; the difference in its state from a condition as soft as copper to one as hard as glass being due to the modifications of carbon." Up to recent times the distrust of steel was so great that marine and civil engineers were afraid to use it. In the early days of the Pennsylvania railroad its steel rails were imported from England, bent to the curves of the roadbed. As a superior metal for cutlery and tools it brought a fancy price of 36 cents per pound. To-day our battleships are sheathed with thousands of tons of the best steel, and 800 tons are used yearly in the manufacture of steel pens. Carbon-steel was a great improvement over iron, and the use of nickel in steel is found, in all cases in which careful investigation has been made, to mark a further improvement in the manufacture of steel. A German authority has recently observed that, considering the mutual affinity of nickel and iron, as shown by the presence of nickel in meteoric iron, it is remarkable that the example of the handiwork of Nature had not been copied before this.

Riley's testimony to the value of nickel steel.

In a paper read before the Iron and Steel Institute, Mr. James Riley, manager of the Steel Works of Scotland, says:[13]

> "If the engineers of those stupendous structures (the Forth Bridge and the Eiffel Tower) had had at their disposal a metal of 40 tons (ultimate) strength and 28 tons elastic limit, instead of 30 tons strength and 17 tons elastic limit in the one case, and say 22 tons strength and 16 tons elastic limit in the other, how many difficulties would have been reduced in magnitude as the weight of material was reduced!"

Mr. Riley's paper was the first to present publicly the merits of nickel steel, and attracted much attention.

Tests of its utility for armor plate in the United States.

Just about that time the Ordnance Bureau of the United States Navy Department was seeking the best type of armor-plate for the new battleships, and the superior qualities of nickel steel were brought to the attention of the department. Secretary Tracy authorized a comparative trial of three armor-plates forged at the largest steel-works in France and England, and representing the best types of simple steel, nickel steel and compound (hard and soft) steel armor plates. The result of this trial, in September, 1890, indicated so strongly the superior merits of nickel steel that Congress was justified in granting an appropriation for the purpose of purchasing the necessary quantity of nickel to continue experiments. These experiments were uniformly successful, and the Navy Department adopted nickel steel for armor plate, and wherever possible in the work of the Ordnance Bureau. Nickel steel armor of the best quality is now regularly produced by two of the large steel works of Pennsylvania, the Bethlehem Iron Co. and Carnegie, Phipps & Co., which have special facilities for handling this class of work. The former concern forges all its plates, while the latter employs rolls.

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[13] Alloys of Nickel and Steel, Journ. I. and S. Inst., No. 1, 1889, p. 54.

Harveyized nickel steel.

The Harvey process of hardening the face of nickel steel armor by cementation to the depth of several inches, with subsequent water-hardening, is an important advance in making nickel steel armor still more effective.

The type of armor plate used by the British Admiralty is a compound plate made up of a hard steel face and soft steel backing. They considered the question of the best armor for their battleships as settled in 1878, when they adopted this type of armor plate. Comparing the relative depth of penetration in the Harveyized nickel steel, all steel, compound and soft steel armor plates, the ratio of superiority in favor of the Harveyized nickel steel plate is as follows, in the order named :

Relative penetration.	Kind of armor plate.	Relative resistance.
1.	Nickel steel, Harveyized.	1.
1.64	All steel.	0.609
1.75	Compound.	0.572
2.2	Soft steel.	0.455

So that for equal power of resistance there can be a saving of 48.8 per cent. in weight in favor of the Harveyized plate over the compound plate.[14] The ordnance trials at the Indian Head proving grounds are as severe as any in the world ; and it is with pardonable pride that the Bureau of Ordnance of the Navy regards the placing of an order for nickel steel armor plate by the Russian government with the Bethlehem Iron Company as an acknowledgment that we have to-day the material and facilities, and are forging in this country armor and projectiles that have no superior in the world.[15]

Krupp of Essen is furnishing for vessels of the "Brandenburg" class in the German navy nickel steel armor made on a new system. The plates are 5½ inches thick, and show a resistance equal to plates of 9¾ inches made by the old system.

The French government uses an armor plate containing 0.4 per cent. carbon, 1 per cent. chromium and 2 per cent. nickel.

Nickel furnishes toughness and chromium hardness. It is in the highly desirable qualities of extreme toughness and elasticity that nickel imparts valuable properties to steel, increasing its resistance to shocks and hindering crystallization.

The Bureau of Steam Engineering, United States Navy, has had the two intermediate line shafts of the Iowa and the two propeller shafts of the Brooklyn made of nickel steel by the Bethlehem Iron Company. The line shafts are 15¾ inches outside and 9¾ inches inside diameter, while the propeller shafts are 17 inches outside and 11 inches inside diameter ; the walls being in both cases 3 inches thick. The government specifications require a tensile strength of 85,000 lb. and 50,000 lb. elastic limit. Six test pieces from one of the propeller shafts of the Brooklyn gave the following results:

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[14] See Stahl u. Eisen, No. 4, 1893.

[15] See article "British Armor and Ordance," London Engineer, March 23, 1894.

Nickel steel propeller shaft for U. S. ship Brooklyn.

Hollow-forged, oil tempered, rough-machined. Outside diameter, 17⅛ inches; inside diameter, 11 inches; length, 38 feet 11⅝ inches; weight, 19,112 pounds. Test bars cut from this tube gave the following results:

Dimensions of specimens.	Tensile strength.	Elastic limit.	Elongation.	Contraction.	Fracture.
in.	lb. per. sq in.	lb. per sq in.	p. c.	p. c.	
0.496 by 2	94,185	58,995	26.4	60.83	Dense gray lipped.
0.497 by 2	94,245	60,770	25.55	60.58	"
"	93,215	58,740	25.8	61.33	"
"	93,730	60,770	25.8	59.81	"
0.498 by 2	92,410	59,550	28.0	60.74	"
"	90,350	56,470	28.0	60.74	"

It is to be noted that the elastic limit of this shaft is about equal to the tensile strength of a shaft made of ordinary mild steel, while the elongation and contraction of area are nearly the same.

Tests of hollow nickel steel and solid soft steel shafts,

A comparison of the strength of the nickel steel shafts of the U. S. vessels Brooklyn and Iowa, within their elastic limits, with that of solid shafts of the same sectional area made of soft, simple steel, having an elastic limit of 30,000 pounds per square inch, and also a comparison of their weights per linear unit with that of solid soft steel shafts of equal strength, may be of interest. The following table gives the results of calculations made by Prof. Mansfield Merriman, Lehigh University, Pa.:

Case I. Comparison of three steel shafts.	Propeller shaft U. S. S. Brooklyn. Hollow. Outs. diam. 17 inches; ins. diam. 11 inches. Nickel steel, e. l. 50,000 lb. per sq. in.	Solid shaft, same (approximate) sectional area. Diameter 13 inches. Simple steel, e. l. 30,000 lb. per sq. in.	Solid shaft, same strength under applied loads or horse-powers. Diameter 18.90 inches. Simple steel, e. l. 30,000 lb. per sq. in.
Area of section, square inches..	131.95	132.73	280.55
Weight per yard, pounds	1,346	1,354	2,861
Comparative strength under applied loads in flexure, or under applied horse-power in torsion	307	100	307
Load, in pounds, at middle of a span of 12 feet on two supports, which strains to one-half elastic limit	276,200	89,900	276,200
Length of beam on two supports, which is strained by its own weight to one-half elastic limit	121 ft. 6 in.	77 ft. 6 in.	83 ft. 4 in.
Horse-power transmitted at 50 revolutions per minute when strained to one-half elastic limit	15,780	6,130	15,780

Case II. Comparison of three steel shafts.	Intermediate line shaft U. S. S. Iowa. Hollow. Outs. diam. 15¾ inches; ins. diameter 9¾ inches. Nickel steel, e l. 50,000 lb. per sq. in.	Solid shaft, same (approximate) sectional area. Diameter 12⅜ inches. Simple steel, e.l. 30,000 lb. per sq. in.	Solid shaft of same strength under applied loads or horse-powers. Diameter 17.71 inches. Simple steel, e.l. 30,000 lb. per sq. in.
Area of section, square inches.	120.17	120.28	246.34
Weight per yard, pounds	1,225	1,227	2,513
Comparative strength under applied loads in flexure, or under applied horse-power in torsion	293	100	293
Load which, at middle of a beam 12 feet in span on two supports, causes strains equal to one-half elastic limit, pounds	227,200	77,500	227,200
Length of beam on two supports which is strained by its own weight to one-half elastic limit	115 ft. 6 in.	75 ft. 9 in.	80 ft. 8 in.
Horse-power transmitted at 50 revolutions per minute when strained to one-half elastic limit	12,980	4,430	12,980

and their relative merits.

The hole in a hollow forged simple steel shaft of 15½ inches outside diameter is 7 inches. Nickel steel hollow forged shafts having the same outside diameter may have a hole of 11¾ inches diameter. But for fear of any possible chance of buckling, the hole is made 9¾ inches in diameter. The propeller shafts of the American Line steamers St. Louis and St. Paul are of nickel steel; they will stand 42½ tons breaking strain per square inch, and show 28 per cent. elongation and 50 per cent. reduction of area per square inch. The shaft of the Iowa will stand 45 tons breaking strain per square inch, while 33½ tons is the limit in ordinary steel shafts.

"Here then is a material admirably suited to the shafting and engine forging required by the marine engineer of modern high service engines, and it is believed that as its merits become known its use will be widely extended. In the highest development of the modern marine engines, reduction of weight of all parts is of prime importance. This can only be accomplished by reducing sectional area. On the other hand, outside dimensions cannot be usually reduced without sacrificing necessary stiffness. We are therefore led to removing the metal along neutral axes, or, in other words, to the use of hollow forging. It is evident that to farther reduce weight, as well as to increase the absolute strength of parts, the designer of marine engines needs a stronger material than that now employed; that is, a material having a greater elastic limit, but at the same time possessing such a degree of toughness as to insure resistance to sudden strain and shock. Simple steel strengthened and toughened by tempering and annealing will show, in specimens cut from the center of sections, say 3 inches to 6 inches thick, an elastic limit of about 45,000 pounds per square inch, an elongation of about 23 per cent., and a contraction of area of from 50 to 55 per cent. A farther and very pronounced improvement in strength and toughness can be obtained by the use of nickel steel, tempered and annealed as above described. The use of nickel allows a reduction of carbon, makes the steel more sensitive to temper, and facilitates the tempering of irregular shapes. Specimens from nickel-steel forgings, tempered and annealed, will show uniformly an elastic limit of from 50,000 to 55,000 pounds per square inch, an elongation of 23 per cent. and above in specimens 2 inches long by ½-inch diameter, and a contraction of area of from 55 to 60 per cent. In cases where, owing to thickness of sections and irregular shape, tempering is not advisable, nickel steel will still show a higher combination of elasticity and toughness than any other material known, under the same conditions."[16]

OTHER USES OF NICKEL STEEL.

Nickel steel for ordnance.

A complete set of nickel steel forgings for an 8-inch gun has been made by the Bethlehem Iron Company for the Bureau of Ordnance, United States Navy, and is now being assembled at the Washington navy yard. The average physical qualities obtained in these forgings in transverse specimens were:

—	Tensile st. lb. per sq. in.	Elastic limit lb. per sq. in.	Elongation p. c.	Contraction of area p.c.
Tube	93,200	58,300	21 2	42.0
Jacket	99,900	60,000	20.4	45.9
Hoops	109,100	68,200	20.5	46.9

Test specimens were 2 inches long by ½-inch diameter. Comparing with the average of qualities usually obtained in corresponding navy gun forgings made of simple steel, the tensile strength shows an increase of about 10 per cent., with an increase in elastic limit from 22 to 28 per cent., while the contraction of area and elongation are but slightly reduced.

small arms,

The Bureau of Ordnance found while experimenting that two small-arm barrels showed greater endurance than others. They were respectively of a very high-carbon steel and a steel containing about 4½ per cent. of nickel. The latter was fairly easy to machine, while the high-carbon steel was almost intractable. Consequently the Bureau decided to adopt nickel steel for its small-arm barrels. The great excellence attained by the Greener gun is attributed to the use of nickel steel barrels containing 2.75 per cent. of nickel and 0.2 per cent. of carbon.

structural steel, etc.

It is evident that, besides the application to which nickel steel is being put in armor plate, gun forgings and marine shafting, there is a still wider field open to its use for structural steel, heavy castings, car-couplers, car-wheels, boiler-plates, small pinions and knuckles, shear-knives, bicycle-spokes, gears for motors, and all varieties of work demanding hardness, toughness and malleability.

Cementation of iron and nickel plates.

Plates of iron or steel and nickel, when laid together and heated to welding temperature, may be rolled out into thin plates with a continuous nickel surface on both sides, or iron or steel on one side and nickel on the other. The union of the two metals is not merely a welding, but is of the nature of cementation, an actual alloy being formed to some depth below the surface of contact. There is a steam vessel in New York harbor sheathed in part, as an experiment, with this material, fastened with iron nails. After eight months constant service the iron nails have corroded away, and all of the bottom except the nickel sheathing is corroded and foul, while the latter is as clean as when first put on. If nickel nails were used, it would seem as if nickel sheathing, or sheet nickel, would make an ideal sheathing for all salt-water craft. This material is also used for lagging steam-cylinders, feed-water heaters, etc. It takes a beautiful polish, and is stronger than brass or copper.

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[16] R. W. Davenport, Vice-President Bethlehem Iron Company, Trans. Nav. and Marine Engrs., vol. 1., 1893.

Use of nickel steel in powerful electric machinery, and

The Niagara Falls Power Company has recently installed four 5,000 horse-power electric generators coupled to turbine water wheels. In this type of generator the periphery of the large rotating field travels at the rate of nearly two miles per minute. The bobbins are secured within a ring of nickel steel that is forged without a weld, having an outside diameter of $139\frac{3}{8}$ inches; inside diameter, 130 inches; width, $50\frac{3}{4}$ inches; weight, 28,840 pounds. This ring of nickel steel is extremely light for its strength, and resists the centrifugal forces of this large field, while adding but little to its weight.

for steam boilers.

The Bureau of Steam Engineering, United States Navy, has decided to put nickel steel boilers in the cruiser Chicago, which is shortly to undergo repairs.

Nickel steel wire for marine service.

Nickel steel containing as much as 30 per cent. of nickel may be drawn into wire as easily as ordinary steel. Wire of this class, containing sufficient nickel to make the non-corroding qualities of the metal prominent, is especially adapted for hawsers and cable service in salt water. A sample of nickel steel wire containing 27.8 per cent. nickel and 0.40 per cent. carbon, used as torpedo defence netting by the United States Navy, gives the following physical test:

Diam. cross sec. inch.	Area of cross sec. sq. inch.	Reduced diameter. inch.	Reduced area. sq. in.	Con. area. p. c.	Elong. in 2 in. p. c.	Load in lb.	Breaking strain per sq. in. in lb.
0.116	0.01057	0.106	0.0088	16.5	6.25	2,100	198,700

The high tensile strength of this wire, with the comparatively small reduction in elongation and contraction of area, indicates extreme toughness; and at the same time it is not acted upon by salt water, so that it admirably answers the requirements of marine service.

FLANGE STEEL.

Tests of flange steel with and without nickel.

The Cleveland Rolling Mill made some flange steel for the Canadian Copper Company, with and without nickel, for the purpose of making comparative tests of their physical qualities. The results are given in the table on the next page.

This nickel steel shows an average increase of 11,400 pounds per square inch, or about 31 per cent. in elastic limit, and an average increase of 10,400 pounds per square inch, or about 20 per cent. in ultimate strength, without any perceptible effect upon the ductility, as evidenced by the percentage of elongation and contraction of area.

Tests at the Canadian Copper Company's works.

The Canadian Copper Company at its works at Brooklyn near Cleveland, Ohio, made a series of experiments on nickel steel with varying percentages of nickel and carbon in an improvised acid bottom open hearth furnace. The heats amounted to about 1,000 pounds of metal, made out of washed low phosphorus pig and high grade Bessemer ore. Nickel in metallic form was charged into the bath about one and one-half hours before tapping. Difficulty was experienced in controlling the heat, and other adverse conditions were encountered on account of the limited scale and lack of facilities in managing such a small furnace, which rendered it impossible to make steel of a uniform grade and show the degree to which a definite percentage of nickel in steel would be influenced by varying percentages of carbon, and vice versa. Still the results of the physical tests of this steel may be of interest. The test pieces were all taken from the center of the ingot, hammered to one and one-half inches square, and then turned down to a diameter of $\frac{5}{8}$-inch, with two inches between fillets, which were $\frac{7}{8}$-inch in diameter and threaded :

Comparative tests of nickel steel and best soft flange steel.

—	Charge. lb.	Reduction of area. p.c.	Elongation in 8 inches. p.c.	Elastic limit. lb. per sq. inch.	Ultimate strength. lb. per sq. inch.
I. Nickel steel. Containing C., 0.08; Mn., 0.36; P., 0.045; S., 0.038; Ni., 2.69.	Basic scrap, 9,000; low-phosphorus pig, 9,000; 80 per cent. ferro, 165; 97 per cent. nickel, 540.	53.	23.25	....	64,080
		53.3	26.	47,100	66,370
		56.3	25.	44,700	66,000
		45.1	24.5	47,400	67,100
		54.4	26.	47,300	64,800
		49.7	23.75	48,900	66,200
II. Soft steel. Containing C., 0.10; Mn., 0.27; P., 0.048; S., 0.039.	Basic scrap, 9,000; low-phosphorus pig, 9,000; 80 per cent. ferro, 160.	45.6	26.	35,700	55,500
		45.8	26.	35,500	54,600
		52.9	27.5	32,800	53,900
		61.8	32.	34,060	52,500
		63.	27.	35,500	53,700
		63.	26.	37,900	56,500

No. of specimen.	Carbon. p.c.	Nickel, p.c.	Ultimate strength, lb. per. sq. inch.	Reduction of area, p.c.	Elongation, p.c.	Length, inches.	Fracture.	Hardness in lathe.
14	0.16	3.35	102,800	29.1	15.0	2	Silky.	Soft, UnA.
14	0.16	3.35	100,650	48.1	27.0	2	Silky.	Soft, A.
19	0.19	2.62	141,100	24.8	11.9	8	Gray.	Hard, Drawn.
13	0.22	2.05	88,880	34.6	20.5	2	Gray.	Easy, UnA.
13	0.22	2.05	84,650	55.4	31.5	2	Gray.	Easy, A.
13	0.22	2.05	83,040	58.2	25.1	8	Gray.	Easy, Drawn.
15	0.31	3.40	109,100	24.4	17.0	2	Gray.	Easy, UnA.
15	0.31	3.40	100,800	49.2	26.0	2	Gray.	Easy, A.
15	0.31	3.40	98,120	44.4	20.0	8	Silky.	Easy, Drawn.
41	0.51	4.93	127,075	27.1	16.0	2	Crystallized.	Hard, A.
24	0.54	3.20	131,200	12.7	10.5	2	Gray.	Hard, A.
24	0.54	3.20	134,400	36.7	14.3	8	Gray.	Hard, Drawn.
29	0.96	3.10	151,880	12.9	8.0	8	Gray.	Hard, Round.
34	0.91	3.10	138,000	22.3	9.88	8	Gray.	Hard, Round.

This steel was quiet in the moulds after tapping, set quickly without piping, and the ingots were smooth and clean. They were submitted to the same treatment in the hammer shop and rod mill as is given to ordinary steel. Through a mistake in getting numbers changed, the bars drawn through the rolls of the rod mill received an extra annealing heat. The conditions of the tests were as near alike as possible; the only exception being that the rods were pulled in the testing machine[17] as they came from the 1$\frac{1}{8}$-inch rolls, in 8-inch lengths, while the other test specimens were 2 inches long and $\frac{5}{8}$-inch diameter.

The specifications of the Baltimore and Ohio railroad for steel tires, and the U. S. Navy Bureau of Steam-Engineering for crank and propeller shafts, connecting and piston rods and ordnance, are as follows:

Specifications of Baltimore and Ohio railroad.

Grade.	Carbon, p.c.	Tensile strength, lb. per sq. in.	Elongation in 4 inches, p c.
I.	0.50 to 0.60	105,000	16
II.	0.60 to 0.70	115,000	14
III.	0 68 to 0.78	125,000	10

Grade I. is for passenger engine tires, outside diameter, 60 inches; grade II., for consolidation, mogul, etc., outward diameter, 45 to 60 inches; grade III., for switching engines, car wheels, and all tires less than 46 inches in outside diameter.

A variation of 10,000 pounds in tensile strength above or below the above figures is permitted.

Specifications of the Bureau of Steam Engineering, U. S. navy.

——	Tensile strength, lb. per sq. in.	Elongation in 2 inches, p.c.	Contraction of area, p.c.
Propeller shafts	85,000	23	....
Crank shafts	58,000	28	....
Connecting rods	65,000	25	....
Piston rods	65,000	25	....
Ordnance	85,000	18	35

An advantage of greater strength with same weight, or equal strength with less weight.

It goes without saying that, where other conditions are equal, soft or low carbon steel possesses advantages over hard or high carbon steel, as it is easier to machine, and (what is of greater importance) may be submitted to much rougher treatment, because it is not subject to the dangerous internal strains of hard steel. It is in this respect especially that nickel steel, having the superior qualities of soft steel, fulfils the requirements of service sought for in hard steel, and offers to engineers the advantages of a material which will give greater strength with same weight, or equal strength with less weight, than any other at their disposal. Comparing the accepted standard of mild steel with nickel steel having approximately the same carbon contents:

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[17] Otis Steel Company's Olsen machine.

——	Tensile strength, lb. per sq. in.	Elongation, p.c.	Contraction of area, p.c.
Ordinary steel................	65,000	23 in 8 in.	48.0
No. 13 nickel steel (2.05 per cent. nickel)..............	84,650	31.5 in 2 in.	55.4
No. 14 nickel steel (3.35 per cent. nickel)	100,650	27.0 in 2 in.	48.1

We have here nickel steel, containing less than 0.2 per cent. carbon, and 3.35 per cent. of nickel (annealed), that more than meets the specifications of the Navy Department for ordnance, shafting, etc., and of grade I. for steel tires on the Baltimore and Ohio railroad.

For grade III., requiring high grade steel, we make the following comparison with nickel steel, annealed, containing 0.20 per cent. less carbon than the required carbon in plain steel:

——	Tensile strength, lb. per sq. in.	Elongation, p.c.
B. and O. railroad steel tires, grade III......	125,000	10 in 4 in.
No. 24 nickel steel...........................	184,000	14 in 2 in.

By 2.0 per cent. of nickel (No. 13) the tensile strength of mild steel is raised 30 per cent., and by 3.35 nickel (No. 14) 41 per cent., without any appreciable change of elongation or reduction of area. "The presence of 4.7 per cent. of nickel increases the tensile strength 35 per cent., and the elastic limit 75 per cent., while the elongation and contraction of area is practically the same."[18]

Value of a high percentage of nickel in the alloy.

In reviewing the results of these experiments, corroborated by the experience of others, it is found that better results are obtained by using more rather than less than 3 per cent. of nickel. The tensile strength and elastic limit of steel increases with the percentage of nickel, up to the point of extreme hardness in machining, and the percentage of carbon has everything to do in raising or lowering this property of nickel steel, as much as in ordinary steel.

Torsion tests of these specimens were made by the Standard Tool Co., Cleveland, Ohio, as follows:

Torsion tests at Cleveland.

No. of specimen.	Carbon, p c.	Nickel, p.c.	Torsion-breaking point in lb. per sq. in.	Degrees of twist in 3 in. before breaking 360° = 1 full twist.
14.......	0.16	3.35	2,325	360 ....
19.......	0.19	2.62	2,150	130 Split.
13.	0.22	2.05	2,434	240 Twisted off.
15.......	0.31	3.40	1,807	355 ....
41.......	0.51	4.93	2,200	120 ....
24.......	0.54	3.00	1,200	60 Split.
29.	0.96	3.10	1,700	60 Split.

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[18] Riley's experiments.

The specimens in these torsion-tests were 1¼ inches square. A number of the specimens were found to be checked and laminated in structure.

Cold-bending test.

In a cold-bending test of a specimen 2½ by 2½ inches (full thickness of wall of forging), 18 inches long, under hydraulic press through 180°, the ends met within ½ inch; the greatest distance between sides was ⅞ inch. There was only one slight crack, in one corner on the inside of the bend.[19]

General conclusions.

The percentage of nickel in all the government work herein referred to is 3 25 per cent., with carbon at about 0.2 per cent. It is not improbable that familiarity with working and cheapening the cost in manufacture will permit the percentage of nickel to be considerably increased above this figure to good advantage. It has been the practice in this country to charge the nickel into the furnace in the form of nickel oxide enclosed in sheet iron boxes. In other countries pig or ferro-nickel is used. Some steel plants use metallic nickel, which offers this advantage over the oxide that less nickel slags off. The best results are obtained in the basic open-hearth furnace. Several of the Pittsburgh steel works use nickel as an alloy for steel, but are not yet prepared to make a special feature of nickel steel castings outside of government work. The Bethlehem Iron Compnay, having enlarged its plant, has special facilities for making nickel steel in any desired form or size for the general trade, besides taking large government contracts.

It is obvious from the foregoing data, which briefly summarize the present status of the metallurgy of nickel, that the field for the use of nickel is one of magnitude, and that the era of its development has only just commenced.

NICKEL STEEL: ITS SPECIAL VALUE FOR ARMOR.[20]

By Captain W. H. Jaques, Ordnance Engineer, New York City.

In responding to a request to prepare an article on some engineering question of importance for publication in a British journal, I take pleasure in selecting one that appears to have been neglected in Great Britain. Whether the neglect is due to omission or commission may be difficult to decide.

An objection to nickel that is rapidly disappearing.

To me as an American it appears as if the neglect was intentional, for the objection to the high price of nickel seems to be rapidly disappearing, and the feeling that British metallurgists cannot secure as good results with nickel as have been obtained in the United States, Germany and France ought to be removed by local accomplishments, as it certainly can be under the advice of those who have already obtained such favorable and useful results.

In relation to the price of nickel, the last report of the directors of H. H. Vivian & Co., Limited, gives ample data.

Experience of the H. H. Vivian Co.

"At the commencement of the twelve months," it reads, "the selling price of nickel was about 1s. 9d. per lb. net, while at the end it had been sold as low as 1s. 3½d. per lb. The loss on the nickel and cobalt trade of Hafod Isha Works was £15,102 10s. 7½d., of which £13,340 15s. 11d. is entirely attributable to the reduction in the value of stocks. The difference between the two sums is due to constant fall in prices of current sales during the year. A loss of £1,299 15s. on the Murray mine arises from the value of the nickel product being credited at less than cost, although this mine has produced, and is producing, at a low rate. A loss of £3,764 12s. 1d. on the Evje mine is very vexatious. When the directors took a lease of this mine the value of nickel was about 2s. 9d. per lb., at which it was capable of working profitably. The fall of nickel to prices previously mentioned upset all calculations, and converted the anticipated profit into a loss."

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[19] Laboratory of Lehigh University.

[20] Published in the Engineering Review of London, Eng., February 20, 1895.

No doubt some companies and some nickel mines will have to be sacrificed in the progress. But did this not occur to the iron industry when steel so completely replaced iron? What sadder evidence of this than the black Birmingham district? And to how many other industries would this apply?

The best and surest way of reducing prices.

The best and surest way to reduce the price of nickel is to make a commercial demand for it strong enough to encourage its production in the various forms in which it can be most successfully employed. Take aluminium for example; who would have thought five years ago that this metal could be sold for 40 cents a pound. To-day makers will be glad to sell it for that, and no doubt before this new year is finished users of it will be able to obtain it for half that price.

In regard to supply, the Canadian mines alone can more than meet the demand. In fact it has been reported that an American company supplied last year 70 per cent., if not more, of 1894's consumption by the entire world.

The popular clothing of armor to-day is carbonization.

Techincal value of carbonization.

In regard to its technical value, and the very prominent part that nickel is now taking in the development of steel, I cannot better express my opinion than by repeating the views I presented at the last meeting of the American Society of Naval Architects, and which have been published or quoted in various technical journals. They are given here to emphasize the recognition of a most valuable metal, not only for use in the production of armor, guns and other war material, but in boilers, plates, shafting, piston-connecting and hammer-rods, where better physical and wearing qualities are demanded.

The decision of the British Admiralty questioned by other experiences.

The British makers have given up the compound type to which they so tenaciously held, and all European manufacturers of armor have adopted the carbonized all-steel, using more or less carbonization or surface hardening in accordance with their own special views, and employing a variety of methods to secure the surface hardening. Great Britain has acknowledged our supremacy in the armor question, and partially imitated our methods; but, for some reason not yet publicly explained, the employment of nickel in armor has been officially announced as an unnecessary increase in the cost of its production. Considering the benefits that its use has demonstrated in steel for many other purposes as well as armor, it is difficult to accept this decision on the part of the British Admiralty.

The attempts to demonstrate the value of nickel in steel have been very unfortunate in England, and the question naturally arises, Why is nickel steel so expensive as to preclude its use there? The United States' steel workers have had better success with nickel than even French makers, although to Mr. Schneider, of France, belongs the credit of introducing nickel in steel.

Krupp's nickel steel plates have shown splendid results; while Bethlehem, Carnegie, St. Chamond, and even Brown and Vickers, have given many practical evidences of the value of nickel in armor steel. Perhaps if Vickers had introduced the right proportion of nickel in the composition of his plate tested at Texel in August of 1893, and if it had been properly worked and treated, he would have won on resistance and not lost on brittleness.

The tests of thick armor which excited the most interest during the past year, and carried with them the greatest commercial risk were the 17-in. and 18-in. nickel steel carbonized plates for the United States battleships. While the most resisting *individual plate* tested was *nickel steel carbonized*, the ballistic tests failed to demonstrate the limit of the dimensions to which the carbonization process could be advantageously applied.

On the contrary, in every case where nickel was employed in the United States, Germany and France, excellent results have been obtained. Uniformity, which is one of the characteristics most to be sought for, appears to be best obtained in the nickel steel type. If this is secured, even at a slight reduction of ballistic resistance, the certainty of having a product of uniform quality is a marked advantage.

In connection with chrome very good results have also been obtained. The large quantity of nickel used by the St. Chamond Steel Works is another very practical demonstration of the estimation in which it is there held.[21]

The placing of a contract for armor in the United States by Russia is a revolution from the usual methods and influences of the European makers. While the remarkable success which Bethlehem secured while I was connected with the manufacture there had much to do with this result a most important element of the transaction was the decision to use *nickel steel* plates, *not* carbonized; for the order was only secured by a serious cut in prices, the contract being merely for the belt armor of two Russian battleships (600 tons for each of 15-in. taper 8-in.): a large remaining tonnage is left to be supplied by other makers.

The decision of greatest importance therefore is the estimate that Russia has placed upon the use of nickel.

The value of Riley's work.

Not only English but other scientists are familiar with Riley's work demonstrating the value of nickel in steel. His experiments were certainly favorable enough to induce any steel maker to make use of this new, and, for many purposes, more valuable steel, unless personal sentiment or influences were stronger than prospective commercial and technical worth.

Other nations have made good use of the results Riley published; large nickel properties were bought, syndicates were formed, even Great Britain formed a corporation, in which were associated the names of eminent men; and yet in connection with armor alone we read that the British Admiralty has concluded that:

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[21] The N. Y. Engineering and Mining Journal of March 30, 1885, refers to a test recently made at Indian Head of an armor plate manufactured under what is known as the Chase-Grant process, which according to the Ordnance officials is the application of a chrome face to a steel plate. Armor similar in character was tested last September at the army proving grounds at Sandy Hook, and on the first fire was smashed to pieces. The same results attended the plate tried at Indian Head. It was 5 ft. square and 10 in. in thickness. One shot was fired from a 6-in. gun—an armor piercing projectile weighing 100 lb., having a striking velocity of 2,104 feet a second. The shell was stopped and broken up, but the plate suffered severely from the impact, being cracked to pieces.

"In the course of the experiments the use of nickel as an alloy of steel for the purposes of armor plates has been fully tested. It has been established that Harveyed plates without nickel in the steel show resistance to modern projectiles as great as any hitherto obtained when nickel was combined with steel in plates also treated by the Harvey process. The consequence of adopting this new system will be a great saving in cost for a given defence."

Slowness of the Admiralty officials.

Will Great Britain wait another eighteen years (as she did with the Ellis method of carbonization, now publicly known as the Harvey process) before recognizing the great value of the processes which have reduced the cost of this valuable metal, and by its incorporation increased in so marked a manner the physical qualities of material of which engineers are constantly demanding increased strength and endurance?

Will she wait until by the individual efforts of a Fox, or by some other social or personal force, nickel is given in England that position in the metallurgical world that its importance and usefulness demand?[22]

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[22] Captain Sampson, chief of the Bureau of Ordnance of the United States Navy, in a paper read before the Society of Naval Architects and Marine Engineers, makes the following comment on the opinions of the British naval authorities:

"The decision of the Armor Board of 1890 that the Schneider nickel steel plate was softer than that of steel, and allowed greater penetration, was correct for those two plates. Our armor makers however have had no difficulty in making oil tempered nickel steel armor far stronger and more resisting than that of simple steel, while it still retains the characteristic toughness of the nickel. To any metallurgist acquainted with the infinitude of results that may be obtained by a variation in the composition and treatment of simple steel, the advantageous possibilities arising from the introduction of so benign an ingredient as nickel must be apparent. In other words, where simple steel is strong and tough, both qualities may be improved by adding the proper amount of nickel.

"The susceptibility of nickel steel to treatment is remarkable, and yet this steel may be abused in the most shameful way without failure. For this reason the smaller percentage of losses in manufacture will go far toward wiping out the increased cost of machining the tougher material. Nickel appears to render the carbon more sensitive to hardening, and hence water hardened Harvey plates of nickel steel are toughened at depths hardly affected in simple steel plates. Not only that, but the hardening is accomplished with less risk to the plate, and it is for this reason that the manufacturers of the Loire have been able to forego entirely oil tempering armor plates and obtain the increased resistance due to the more severe operation of water hardening. Doubtless the difficulty of spontaneous hardening, which Mr. Ellis mentions as occurring in carbonized nickel steel plates, is due to the sensitiveness of the alloy after its long heat soaking, the plates being removed from the cementing furnace or uncovered in a cold, moist atmosphere while still at a high temperature. It is very rare that any difficulty of this sort occurs in the United States.

"In fact, the only doubt concerning the use of nickel in this country is the feasibility of raising its percentage, now 3.25 per cent., still higher, the improvement and cheapening of the processes of reduction having considerably reduced its cost. In this connection it is well to note that in the Pola, Austria, competitive armor trial of November, 1893, a Witkowitz unhardened plate, said to contain 5 per cent. of nickel, defeated five competitors, including a Vickers Harveyed simple steel plate and a Krupp gas hardened plate. These plates contained between 2 and 3 per cent. of nickel. Finally, in England, where the nickel in Harveyed armor rarely exceeds 2.5 per cent., its peculiar toughening effect is taken advantage of by employing it for unbacked structures, while the Harveyed all steel armor, being more susceptible to racking, is now only fitted on backing. There is therefore nothing in the present application of the Harvey process, nor its future possibilities, to indicate the disuse of nickel in armor; rather that by increasing its percentage the toughness of the foundation plate and its resistance as a whole may be increased.

"The service tests for Harveyed plates for United States naval vessels require them to withstand two shots, the first delivered with the velocity which, according to the Gavre formula, would cause the perforation of a wrought iron plate 10 per cent. greater in thickness, together with 36 inches of oak backing, the requirements being that no crack shall extend from the impact to the edge, or from one edge to another of the plate, and at the same time through the entire thickness of the plate at an edge. The second shot is at the velocity which according to the De Marre formula would cause the perforation of a Creusot steel plate 15 per cent. greater in thickness, together with 36 inches of oak backing, the requirement in this instance being that the projectile or any fragment thereof shall not pass entirely through the plate and backing.

"These tests are but 15 per cent. more severe than those required for oil tempered nickel steel plates, and are now 3 per cent. less severe than those fixed by the latest contracts in France. It has been claimed that the larger calibers employed in France make the test more severe. This is hardly the case, as in France cracking is not barred. The plate must resist perforation, no part of the backing must be exposed, and the plate must remain in such condition as regards cracks as to enable a second shot to be fired upon it. The velocity of the second shot will be 1.26 as compared with that for ordinary steel as obtained from the De Marre formula, and the blow of this shot shall fall at a point distant 3 to 4 calibers from the first. Should the plate stop this shot a premium of 8 per cent. of the contract price will be paid. Should the plate fail to fill the conditions imposed for the first shot, then another shot will be fired with a velocity of 12 per cent. greater than that capable of piercing an equal thickness of steel, and if the plate successfully resists this attack the lot may be accepted, but at a price reduced 8 per cent. below that agreed to in the contract.

"It would thus seem that the minimum requirement in France after all is hardly as severe as our own; still there are three grades of quality, and three prices under the same contract. It must be remembered however that the tests in the United States do not, as abroad, fix a standard of excellence. They mark the inferior limit, as does the last shot mentioned in the French contract above. The poorest, not the average plate, in an armor group of 300 to 500 tons must pass this test, or the entire lot is rejected."

SECTION VII.

MINING ACCIDENTS.

Too high percentage of accidents.

The past year has again been marked by a disproportionately large number of accidents, of which an unusually high percentage were of a fatal character. In seven casualties, involving fourteen men, seven men were killed and seven others more or less severely injured. The falling of pieces of rock from the roofs and sides of underground workings is in all countries one of the most prolific sources of accident, and in the mines of our own province last year it was responsible for the death of six out of the seven men killed. Even in the coal mines of England where explosions of fire damp of great magnitude and severity occasionally occur, causing the death of scores and sometimes hundreds of miners, falls of coal and rock far transcend any other single cause of fatal accident, and indeed go far to bring about as many calamities as all other causes combined. Thus, in the eleven years 1875-85, there were 12,315 deaths in the English coal mines from accidents of all kinds, underground and surface, of which 5,021 were due to falls of coal and rock from roofs and sides, while only 2,903 were caused by explosions, notwithstanding the fact that in the latter case there were at least two instances where upwards of two hundred men were killed at one fatality, and six where more than a hundred met their death at one time, while as a rule the deaths caused by falling coal or rock occurred singly, or at most in small numbers at a time. For the twenty-two years 1873-94 the total number of accidents was 23,808, of which 9,992 were due to falls of ground and 4,575 to explosions of fire-damp. Under the closest and most careful inspection, and in the face of what is considered to be ample provision against danger by way of timbering and other means of support, it seems almost inevitable that hidden seams and fissures will lurk in the darkness of the mine ready when least expected to let slip the loosened masses upon the workmen below.

Falls of rock a prolific cause.

Illumination of mines.

It is evident that a valuable aid in the prevention of accidents from this cause would be an efficient system of mine lighting which would disclose cracks and fissures that might otherwise escape unnoticed, and which would also reveal the first symptoms of impending disaster. Where the sole source of light is the candle in a miner's cap, sufficient only to enable him to see the few feet of ground which he is engaged in working, even the keenest vigilance will sometimes fail of ensuring safety. The problem of illuminating underground workings on a large scale, either by a fixed light or temporarily for purposes of making examinations, has not as yet come to the front in this province, for the reason that operations at any considerable depth are few in number. It would offer some difficulties, among which would be the smoke caused by blasting, nearly always present in the atmosphere below ground when workings are continuously carried on; but if the development of the industry makes the progress which is hoped and looked for, mining companies and proprietors may find it necessary to give this matter their serious attention.

Necessity of constant vigilance.

Under the most favorable circumstances however it is not always easy to detect the lines of fracture present in the roofs and walls of mines, which may be due to the action of frost and water, to movements in the earth's crust, or to explosions of powder within the mine, and their presence may be, and in nearly all cases is, unsuspected until the fatality takes place. Yet it would seem possible by providing good light, by systematic and sufficient timbering, by constant scaling, and above all by incessant watchfulness, to take such precautions as would reduce the danger to life and limb from this cause to a minimum. In a mine eternal vigilance is the price of safety, but the experience of other lands goes to show that while it is not practicable to eliminate the element of danger, it is possible to rob the business of very much of the risk which is attendant upon it where the proper safeguards are either neglected or the necessity for their adoption is not understood.

One source of danger eliminated.

It is satisfactory to note that one cause of accident which figured prominently in the Report of 1893—that of the explosion of powder in heated ore—is altogether absent from the Report of 1894. The steps taken by the Bureau to put an end to the hazardous practice of breaking up hot roasted ore by inserting in it charges of dualin, which had reached a dangerous prevalence in the former year, enforced as they were by enactment of the Legislature, have doubtless been the means of abolishing the custom, and so removing this source of risk from the list of causes of mining accidents in Ontario.

The accompanying table on page 201 gives particulars of the various accidents.

THE OPHIR DISASTER.

Serious fatality at Ophir mine in Galbraith.

The first and most serious fatality of the year was that at the Ophir gold mine in the township of Galbraith on the 5th of March, by which Frank Pacey, James Hoath and Anthony Savage were killed, and Samuel Sanders (or Mudge), David Johns and William Chapman were slightly hurt. A mass of rock became detached from the hanging wall and fell on the heads of the unfortunate miners who were working below it, killing them instantly. A despatch in the Toronto papers gave brief intimation of the occurrence, but no notification having been received from the company as required by the Mines Act, the manager, Mr. J. K. Owen, was communicated with by the Bureau and particulars of the accident requested. On receipt of Mr. Owen's reply the Inspector of Mines, Mr. A. Slaght, was instructed to proceed at once to the scene of the disaster and make a thorough investigation into its causes. Meantime the mine officials had notified Dr. McCort of Thessalon, coroner for the district, of the accident, who visited the mine and after making inquiry decided that it was not necessary to hold an inquest. The Inspector, who was directed to inquire into the advisability of an inquest, also reported that in his opinion one was not imperative. His report, the essential parts of which are given below, went to show that the accident could not have been foreseen, and was therefore unavoidable. In view however of the very

TABLE OF ACCIDENTS IN 1894.

Mining accidents in 1894.

No.	Date.	Company or firm.	Mine.	Name of injured person.	Nature of injuries.	Cause of accident.
1	Jan. 8 ..	H. H. Vivian & Co..	Murray	James Stenton......	Burned about the legs......	Upset pot of semi-molten metal on icy floor.
2	Mar. 5 ..	Ophir Mining Co	Ophir	Frank Pacey	Killed	Fall of rock from roof of mine.
				James Hoath	Killed	
				Anthony Savage....	Killed	
				Samuel Sanders	Slightly injured	
				David Johns	Slightly injured	
				William Chapman..	Slightly injured	
3	April 11 ..	Canadian Copper Co.	Copper Cliff ..	Robert Wightman..	Hip bruised	Jammed between car and wall.
4	June 6 ..	H. H. Vivian & Co..	Murray	Thomas Trethewey .	Hip dislocated; otherwise bruised	Knocked over high stope by drill shell working loose.
5	Sept. 15 ..	Canadian Copper Co.	Copper Cliff ..	Thomas Lintley	Killed	Fall of rock.
				Samuel Mattson	Killed	
				John Mitchell	Slightly injured	
6	Nov. 24 ..	Canadian Copper Co.	Copper Cliff ..	Axel Johnson	Killed	Fell down shaft.
7	Dec. 10 ..	Canadian Copper Co.	Copper Cliff ..	William Martin	Killed	Precipitated down shaft by fall of rock.

Summary: Killed, 7. Injured, 7. Total, 14.

serious nature of the accident, and of statements which were made to the effect that previous to its occurrence the workmen had demanded that the mine should be timbered, and had in fact threatened to quit work the next Saturday unless this were done, it was deemed proper to order an inquest to be held, and Dr. Scherk of Sault Ste. Marie was accordingly instructed by the Attorney-General's Department to make an official investigation. Mr. J. J. Kehoe, District Crown Attorney, was detailed to assist in the inquiry in order that the facts might be fully brought out. Owing to the unavoidable absence of Mr. Kehoe, it was found impossible to begin the inquest until the 20th of March, fifteen days after the accident. Adjournment was made on that day to 3rd April, when the inquest was concluded. Meantime of course the bodies of the unfortunate men had been buried, but the corpse of Anthony Savage was exhumed, and although the inquest was nominally into the cause of his death only, the investigation covered the cases of all three, their deaths being practically simultaneous and due to the same cause.

n investigation by a coroner ordered.

INSPECTOR SLAGHT'S REPORT.

After setting forth the instructions which he had received from the Bureau, and the preliminary steps of his inquiry, the Inspector goes on to say in his report addressed to the Honorable the Commissioner of Crown Lands:

Report of the Inspector to the Commissioner of Crown Lands.

On arriving at the mine Friday, March 9th, I was met by the superintendent, who had been advised by the Director of Mines of my coming to investigate the accident, and he stated that whatever assistance could be rendered by the officials would be readily given. On going to the place of the accident I found nothing had been removed or changed other than was necessary to take out the bodies of the victims. A mass of rock (perhaps 10 tons) had fallen from the hanging wall underneath which the men were working at the time of the cleavage. The place where it severed from the wall was about fifteen feet in width at the top, ten feet in height, and in a V shape, the point coming down near the floor. The piece was eighteen inches or two feet in the thickest part, tapering to the edges. It could readily be seen after it had fallen that a seam was between it and the more solid formation from which it had broken. It was a small fold or slab lying against the wall. The overhanging wall has a dip of about 60° at the point where the accident occurred, and an elevation on that incline of about thirty-five feet to the rock roof above. I took measurements of the whole interior workings and made the accompanying tracing to show the condition of the mine as nearly as possible.

Condition of the mine at time of the accident.

The mine had at first been worked from the surface, on which there are three openings. The mineral vein was followed down to a depth of about twenty-five or thirty feet and then worked lengthwise, leaving a rock roof, except at places of surface openings, of say twelve or fifteen feet in thickness. The width between the foot and hanging walls is about sixteen to eighteen feet. No rock pillars were left, nor timbers put in to support the hanging wall, which should have been done and continued as the work progressed. The length of this opening extended about 180 feet, rising nearer the surface along the cutting. At a distance of about 100 feet from the workings above, a perpendicular shaft had been sunk at the base of the hill 100 feet or more in depth, with a view of tapping the vein. Also another incline shaft, following the dip of the vein, had been sunk with a view of intersecting the vertical shaft, but I was informed the connection was not made. These shafts are closed and filled with water. The more recent workings were begun at a point lower down the hill, say eighteen or twenty feet, on the vein and an adit run in removing the ore between the walls to the upper workings as the work proceeded. A car track is laid on the floor and continues over a trestle tramway into the top of the mill, over which the ore is carried to the mill in small cars. At a distance from the entrance, say thirty feet, a large barren rock or horse was encountered, part of which was left standing as a support to the wall. After passing the barren rock (which was of considerable thickness) the ore had been taken out between the walls and the working continued to the distance of ninety feet from the entrance to the place of the accident. Part of the ore had also been removed for a distance of fifteen feet farther, where it was intended to leave a pillar to support the hanging wall. The large opening at the surface afforded excellent light for the work below. At the place of accident the distance from the track on the floor to the surface, at the incline of the wall, is forty-eight feet, and about thirty-five feet to the rock roof.

Evidence taken by the Inspector.

When at the mine I took the evidence of all the parties about the works whose statements I considered would be of value in the case, which I herewith submit for your information. Several of the workmen however were absent, having gone to their homes, as work was suspended until all investigations were completed. The coroner, who was early on the ground after the accident, I am informed conferred with all or nearly all the men who had been working in or about the mine recently, before arriving at his conclusion as to the inquest.

Mr. J. K. Owen, superintendent.

Mr. J. K. Owen makes the following statement: I am superintendent of the company's works here, and have had charge of the same since the 15th of November last. I have been associated with the mining industry for about forty years, and part of this time I have had charge in conducting the working of mines, in looking after the men, and in giving instruction as to the manner in which the work was to be done. My experience of this kind of mining work has stretched over a period of at least ten years. I have been of late years more particularly engaged in constructing mills for the treatment of ores. I have built forty of them, and in a large number of cases I have examined the mines connected with them; I have been a consulting party as to how work should be done in them, and in several cases have taken the entire oversight of the work. I also had charge of a gravel pit which required the most difficult timbering to be done. I gave personal supervision to the work in this mine, and began the work on the floor where the tramway is placed. I am in the mine every day, and give instruction to the captain if I think any part of his work requires me to do so. We consult constantly together about the work and the safe condition of the mine. On the morning of the accident, before breakfast, we were consulting about the work. I regarded this mine as in a safe condition, and was overwhelmed with surprise at the occurrence of the rock falling as it did, which unfortunately destroyed the lives of three of the workmen. No person ever spoke to me about the unsafety of the mine, nor have any of the workmen ever left the mine on this account. I was often present in sounding or testing the hanging wall, and where any part appeared unsafe I had it removed. I provided a ladder especially for this work, and not long since in concurrence with the captain had staging erected to remove a small slab of rock which did not appear quite safe.

William Rapsey, captain.

Wm. Rapsey makes the following statement: I am the captain of this mine and have had charge since the 23rd of December last. I have had thirty-two years' experience in mining, and for about fifteen years of this time I have had charge of the underground department of the work as captain, and directing how work should be done. I have had a large experience in timbering up mines and looking after their safe condition. At every shift of the men in the mine I have the rock tested with a hammer by sounding, and if any part is loose or in any way dangerous I have that part taken down. From the outside appearance of the mine and the constant testing of the walls I regarded it as perfectly safe, and was shocked when the mass of rock fell causing the death of three men. There were six men besides myself at the place of the accident when it occurred, and I had my hand on the shoulder of one who was slightly injured by the disaster. I can account for the cleavage of the rock only on the ground of the sudden change of the weather thawing out the frost, which was severe in this part of the mine, as just above it is the large opening to the surface. The weather had been mild, thawing and raining two or three days before the accident. About one hour before the fall of the rock a single blast was made near by, and if at all loosened by the action of the atmosphere this may have aided in the cleavage. After the rock had fallen it was apparent that it was a part of the fold adhering to the hanging wall. I have carefully tested this part of the wall several times.

John Smith, miner.

John Smith, miner, makes the following statement: I have had about twenty years of experience in mining. I was acting as captain of Arington hematite iron mine, Michigan, for three years. I have been constantly employed on underground work at this mine since the 25th of November last as a miner. I have worked alternately on the weekly day and night shifts. I never heard any of the men working in the mine say that it was in an unsafe state. I have sounded the walls often and often, and regarded it as safe; I would not have worked in it myself if I had thought there was danger. My shift changed on Monday, the day of the accident, and I was not in the mine when the disaster occurred. I have only known of one small piece of rock falling before. This happened some two weeks ago, just after a blast, and it fell before we got to it to trim it down.

Charles Henderson, laborer.

Charles Henderson, laborer, makes the following statement: I had but three months' experience in mining before I came to this mine last fall, and I have been constantly here since. I was not in the mine when the accident occurred on Monday last, when three men were killed by the falling of rock. I have never heard any of the men working here say that the mine was in an unsafe condition, nor have I ever known anyone to leave the mine on this account. When not working in the mine I work on farms as a laborer. Working with experienced miners, I regarded the mine as safe, relying on their judgment. If I had thought it unsafe I would not have worked in it myself.

Joseph Lee, miner.

Joseph Lee, miner, makes the following statement: I have had twenty-two years' experience in mining, and have had charge of tunneling on the Canadian Pacific railway and also at the work on the canal at Sault Ste. Marie. My experience on underground work has been about ten years in duration. I began work here first of February last, and have never heard anyone say the mine was unsafe. I considered the mine quite safe. If I had thought anything was wrong in it I would not have worked in it. I think the falling of the rock may have been caused by the frost. I judge from my own experience in working in King's mountain on the Cincinnati & Great Southern railway in Kentucky, when during the tunneling it would freeze and then thaw, the rocks would frequently be loosened and fall off. This was eighteen years ago this winter.

Dennis Doe.

Dennis Doe makes the following statement: I have had experience in working in mines for four or five years past for part of the time, and part of the time as blacksmith; worked last winter and also this winter on underground work; worked in this mine since November last, but was not in the mine when the accident happened. I always regarded the mine safe, and never heard anyone say it was unsafe. I cannot account for the rock falling unless by action of the frost.

The Inspector's conclusions.

From the evidence taken, which goes to show that the hanging wall was frequently and carefully examined and lately tested at the place of cleavage, as well as from its present appearance, I regard it as by no means certain that special danger could have been foreseen at this point.

That the captain in charge, as well as the superintendent, both of whom have been engaged many years in practical and difficult mining, regarded the mine as safe does not admit of a doubt. Several of the men constantly working in the mine were also old miners, and they foresaw no danger. The place of accident was exposed to clear light, as a large surface opening at a short distance was directly above it, and this gave favorable opportunity to see any defect in the wall if it had been apparent. In view however of this unexpected falling of rock, which unfortunately proved fatal to the lives of three of the workmen, and also as the present working in the mine is beneath the hanging wall which is exposed to changes by action of frost, I regarded it as necessary to give written specific instructions to have substantial timbers placed as supports under the rock roof, and against the hanging wall, with lagging over the tramway in every part where any falling of rock might occur before any further work was done on the floor of the mine. I also directed that substantial ore or rock pillars be left at suitable distances for supports to the hanging wall as the work proceeds.

The Inspector cannot compel witnesses to give evidence, nor can he take their testimony under oath, and in this case a considerable number of the men who had been working in and about the mine had gone to their homes and were not accessible. It may also be stated that the depth of snow on the hill prevented a very close examination of the formation of rock from the surface. My examination was therefore of necessity somewhat limited, and it was considered under the circumstances that a coroner's inquest would be more satisfactory to determine whether the sad accident was the result of incompetency or carelessness on the part of the management in the mine.[1]

Premonitory symptoms of the disaster.

The information given by the witnesses at the inquest did not bear out the statement that the miners had threatened to abandon work unless the mine were timbered, but it brought out the fact that small pieces of rock had been noticed dropping from the roof shortly before the main body fell. One witness had observed three separate pieces falling during the forenoon, the accident taking place at a quarter past eleven o'clock. It is easy to characterize as recklessness the disregard which the men showed of these warnings, but as the light was good they probably thought—if they thought about the matter at all—that if any seam existed in the roof it would be visible, and consequently paid no attention to the small falls of rock. None of the miners who were examined, including Sanders, Johns and Chapman, who narrowly escaped the death that overtook the other three, regarded the mine as dangerous, notwithstanding the want of timbering. One old miner residing in Bruce Mines, named John Nicholas, who had had twenty-seven years' experience in Canadian, Michigan and Colorada mines, had visited the Ophir in February, 1894, the month previous to the accident, and swore that from the appearance of the mine he then formed the opinion that for the protection of the employés it required to be timbered. It is difficult to resist the conclusion that had extraordinary regard been had by the management for the safety of the workmen a system of timbering would have been introduced.

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[1] By section 8 of the amending Act of 1894 (cap. 16, 57 Vic.) section 67 of The Mines Act 1892 is amended by adding the words: "And in conducting an enquiry into the cause of loss of life or of personal injury to any person in or about a mine, the Inspector shall have power to take evidence upon oath."

But it is easy to be wise after the event, and in the opinion of the coroner's jury, of which Mr. R. E. Miller was foreman, the occurrence was an accidental one, for which the mining company was not responsible. Their verdict was "that the deceased Anthony Savage came to his death by the falling of the rock on him at the Ophir mine, and that the said cause of death was purely accidental, and that no blame is attached to anyone therefor."[2]

Verdict of coroner's jury.

THE FATALITY AT COPPER CLIFF.

The Copper Cliff accident.

An accident similar in character, resulting in the death of two men and the injury of a third, occurred at the Copper Cliff mine of the Canadian Copper Company on 15th September. The men killed were Thomas Lintley, a Finlander, a young married man who left a wife and two small children, and Samuel Mattson, also a young married man, but without children, whose wife was living in the old country. The injuries of John Mitchell, who was also involved in the accident, were slight, and he was able to resume work in a few days. The gravity of the occurrence called for a special investigation by Inspector Slaght, who was accordingly instructed to proceed to the mine and make a report after full inquiry. The Copper Cliff is the deepest of the copper-nickel or in fact any of the mines now being worked in the province, and its underground operations are on an extensive scale. Every facility was afforded the Inspector by the management of the mine for making a thorough investigation. After examining the scene of the fatality and collecting all the evidence possible as to the cause of the accident and the condition of the mine at the time of its occurrence, the Inspector made the following report prefaced by the statements of witnesses of the accident and workmen who were familiar with the state of the workings underground :

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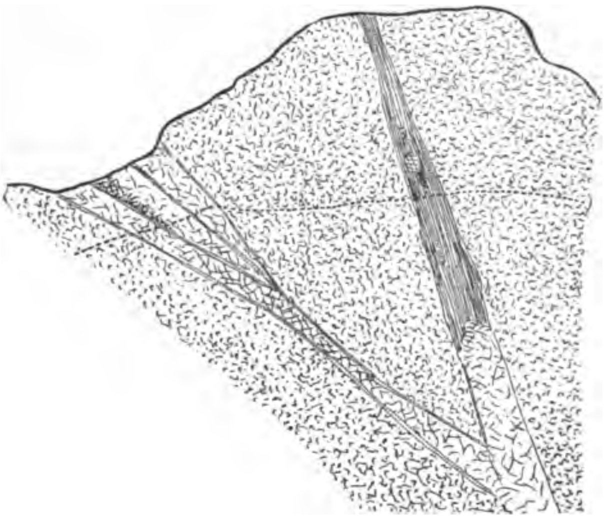
[2] The Ophir mine was inspected by the Director of the Bureau in 1893, and the following extract from the Report for that year (p. 44) deserves to be reproduced in connection with the account of this accident: "My first visit to the Ophir mine was made early in the month of September, when the mill was in course of construction. I returned again in October, a week after the works had started. I found all parts of the mill to be in a safe condition, as required by the Mining Regulations. The mine was also safe at that time; for although stoping work had been carried on to some extent in each of the adits, the roof was well supported by pillars and masses of ore. It was pointed out to the superintendent however that as the roof was evidently cut off from the country rock behind it by the fissure vein, so that it hung like a V-shaped body over the worked-out portion of the mine, it would be necessary to put in ample timber supports before the ore bodies between the several adits were stoped out. In this view the superintendent fully concurred; but his connection with the mine ceased at the end of October." It was this experience of failure to carry out instructions due to the possible change of mine managers, it may be remarked here, which led to the adoption of the regulation for a permanent register of the Inspector's instructions. See p. 214.



REPORT OF THE INSPECTOR.

The Inspector's special report on the accident.

Report and statement of examination relating to an accident in the Copper Cliff mine, which occurred on Saturday the 15th day of September, 1894, when a rock falling from the roof of the seventh level of the mine and tilting over after landing killed two men and slightly injured a third, named respectively Thomas Lintley, Samuel Mattson and John Mitchell.

Charles Jackson, laborer.

Charles Jackson, laborer, sworn: I have been mining four years, and for fourteen months at this mine. I have done almost every kind of work in the mine, and especially running a drill and scaling walls. Where we were working we scaled off every loose part and left the wall good and solid. I have scaled all over the sixth and seventh levels overhead, and other places needing scaling. I have gone over twice these parts of the mine within two months past. I had not heard anyone say that the mine was in any way dangerous before the accident, and have never known anyone leave the mine because it was unsafe. I have regarded it as safe myself, but since the falling of the roof I regard that special place as requiring careful looking after by way of testing it. Ladders sufficient are always kept in the mine.

Charles Gribble, miner.

Charles Gribble, miner, sworn: I have been mining 12 years, and since January at this mine. I have been running a drill; also scaling for my own security and that of my partner. It was a usual practice to scale our own ground. I have not been working for three weeks past because of an accident to one of my fingers. I have heard no parties complain of danger in the mine before the accident. One piece of rock fell long ago. I am not afraid to work in the mine. I regard it safe. Ladders always were in the mine for use in scaling.

John Mackey, miner.

John Mackey, miner, sworn: I have been mining three years, three weeks here. I work in the sixth level. I regarded the mine as safe before the accident. I scaled my own ground.

Fred Dishane, miner.

Fred Dishane, miner, sworn: I have been mining six years and since 1st of May at this mine. I never worked in the seventh level. We scaled our own ground. I always regarded the mine as safe and was not afraid to work in it. A rock fell a few months ago in the sixth level and slightly injured a man. I never knew of any rock falling in the seventh level before the accident an 15th inst. I never heard parties complain of the safety of the mine before the accident.

Joseph Keen, miner.

Joseph Keen, miner, sworn: I have been mining two years and a half, and at the Copper Cliff one year and three months working on a drill, also mucking and trimming the walls of the mine and the roof. We did the scaling as we went along with the drill work. I never knew of any rock falling. One 40-foot ladder and some shorter ones were kept in the mine for scaling. I helped scale up near to the winze about as far as where the rock fell off. Some small stones fell on the sixth level, but not to amount to anything. I considered the mine safe.

Daniel Wink, miner.

Daniel Wink, miner, sworn: I have been mining about twenty-eight years, and seven years at the Copper Cliff and Evans mines. I am shift boss and have acted as such during my connection with the company for some two years at different times. I have worked on the seventh level, and always considered it safe. I scaled the sides and roof as our work went on, but did not scale about the part where the rock fell. I never considered that part dangerous, and I know men were scaling there before. That part was scaled two or three months ago. I never heard any parties say the mine was unsafe, and I always considered it safe myself. I never knew of rock falling in the seventh level. In the sixth some small pieces fell, and then when any of the rock seemed loose it was at once taken down. Ladders and ropes are provided in the mine for this purpose. Scaling is done after every blasting, and a shift of from four to six men go down after midnight on Sunday to look over all loose ground and remove any rock likely to fall. This time is chosen as all smoke is out of the mine and the walls can be clearly seen. This course has been constantly carried on during my term for the past two months as shift boss. Every part of the mine is examined where work is going on and made safe.

Herman Baultz, miner.

Herman Baultz, sworn: I am a miner and have been most of the time engaged for the past eight years mining, and for seven years at Copper Cliff. I have worked at all kinds of work to be done in the mine. I have done a considerable part of the scaling and was engaged for two months at one time steady at it. I have worked constantly in the seventh level since work began this last time, on the 7th of August. I have been working at sinking the shaft. During the latter part of May and June and the early part of July I scaled over the entire roof of the seventh level with three other men, and every part was left solid. I did not see anything defective in the region of the winze, where the rock recently fell causing the accident. We had ladders—two long ones and three short ones—and when one was broken another was supplied. We also had chains and ropes to use for scaling. The seventh level I regarded as all right. I never heard anyone complain that this part of the mine was unsafe, and the men helping me do the scaling said it was all right. I could not say why the rock fell, but think there must have been a slip.

Henry Davis, mining captain.

Henry Davis, sworn : I have been captain of the Copper Cliff, the Evans and Stobie mines for about one year. I have been engaged in mining for over forty years, and have had charge of mines for thirty years, including the copper mine known as the Evergreen Bluff mine, Michigan on lake Superior I had charge of this mine for eight years; also the Jackson iron mine, Marquette county, Michigan, for one and half years; also the Smith iron mine, Michigan, for two years, and the Metropolis iron mine a short time; also the Goodrich mine, Michigan, for eight years and the Ludington mine in the same state for four years. I regard the timbering of the class of mines such as these under my charge as impracticable except in shafts to render them secure, and for the purpose of skips, track ways, and pentice work. I was absent on a visit to my family in Michigan when the accident occurred, and was greatly surprised to receive the news, as I regarded that part of the mine where the rock fell as perfectly safe. I examined the place whence the rock had fallen on Tuesday, on my return, and could readily understand the cause, as slippery seams appeared behind it, and it is probable the concussion by blasting in the mine had loosened it. The piece was an inverted V shape, and would be perhaps a couple of tons in weight. The falling rock on striking the ground tilted over on the two unfortunate men killed. I have given close attention to this as well as every other part of the mine by having the roof and side wall scaled off as the work proceeded, and in addition sent a shift of from four to six men every week after midnight on Sunday to trim the walls and to look the whole of the work carefully over. I selected this time for scaling as the smoke during the Sabbath had entirely vanished from the mine, and the defects could more readily be discovered. In every instance of blasting, the rock is carefully examined and the loose pieces removed. The part of the mine where the accident occurred had been scaled at a not distant date, and was then regarded as all right. It is by no means certain that the defect could have been detected before the cleavage. My long experience in managing mines convinces me that accidents will sometimes occur when and where least expected, and I regard this as one of them, as all reasonable care had been taken for the safety of the workmen.

John Mitchell, sworn: I am underground foreman in the Copper Cliff mine, and have charge of all the work underground. I have had trimmed down all the rock from the roof of the seventh level that needed to come down, and always did the trimming of the walls after midnight on Sunday. It was a convenient time to do this work for the men, and also because the mine was free from smoke. It was something over a week before that the place where the rock fell off was trimmed. That place was regarded as entirely safe, as the ground there had been tried and was supposed to be solid, and I did not go to it. Since I have been in the mine I regarded the seventh level as the best part to work in, and never heard anyone say that it was unsafe. If I had considered it at all unsafe I would not have worked there myself. I never knew of anyone leaving the mine because it was unsafe. Any amount of appliances are at hand to do scaling. Generally I have two to four men with me in scaling at the special time stated, but scaling was done right along as the work progressed daily.

Jno. Mitchell, underground foreman.

The Inspector then states the result of his own observations and his conclusions as follows:

The Inspector's opinion as to the cause of the accident.

The seventh level was the scene of the fatality. The stope in this level is 40 by 90 feet at the floor, and has a raise of 38 feet to the rock roof above, which is 12 feet thick at the winze and increases in thickness as it goes back. The opening is of arch shape, narrowing from near the floor to the roof. At one side a large ore pillar is left as a support to the roof. The formation was firm, and from outward appearances there was no danger of portions becoming detached, and I ascertained that the walls and roof of this level had been recently examined prior to the accident and all loose rock trimmed off. Care was taken to have the whole surface of the walls and roof examined weekly, and when work was being done after each blast scaling immediately followed. The accident occurred near a point where the winze is cut through between the sixth and seventh levels. The size of the fallen mass would average four by five feet by about eighteen inches thick, and would weigh about two tons. The distance from the floor of the level to the roof as before stated would give a fall of 38 feet. I examined the place from which the rock had fallen and found there had been a hidden seam behind it. The detached piece resembled somewhat an inverted V in shape, and was in all probability loosened by the concussion caused by blasting. On the morning of the 15th inst. a blast had been put off in the sixth level, and shortly afterwards the accident happened. I had the rock in the immediate vicinity of the cleavage examined with the aid of a lighted lamp, and tested with the hammer. The test showed it to be firmly placed. The captain I regard as a competent man, and with his large and varied experience, his systematic method of working, and his close attention to the work in the mine by his daily visits to the places of working, there can be but little doubt that all ordinary precautions were taken and reasonable efforts made to prevent accidents. In this particular instance it is barely possible that a more recent examination of the place from which the rock fell might have detected a loosening. However, upon my closer inspection of both the place of cleavage and the rock itself, I am of the opinion that the break was new. I had a sample of rock broken off, and a comparison of it with the side of the fallen mass which had been next the seam strengthened my conviction that the loosening had been simultaneous with the fall. Human life is precious, and a disaster such as the present one is greatly to be deplored, but after a thorough examination of the place of accident, and taking the sworn depositions of numerous witnesses employed in and about the mine, I am satisfied that the operation of the mine was carried on with all due precaution for the protection of the workmen and that no blame can attach to the men in charge.

A coroner's inquest in the matter.

An inquest on the body of Thomas Lintley was held by Dr. McMurchy of North Bay, coroner, and the following verdict was returned by the jury: "According to the evidence given in the accident causing the death of Thomas Lintley on September 15th, 1894, the verdict of the jury is that the accident could not be foreseen, and that the Canadian Copper Company be exonerated from all blame."

AXEL JOHNSON'S DEATH.

Axel Johnson's death at Copper Cliff mine.

The case of Axel Johnson, who was killed at the Copper Cliff mine on 24th November, is next on the list. Johnson is described as a sober, steady young man, thirty years of age, and a Swede by birth. The circumstances under which he met his death were set forth by the Canadian Copper Company in reporting the accident to the Bureau as follows:

The man Axel Johnson, who was killed in our Copper Cliff mine on the 24th ult., was employed as a pump man. We are sinking our shaft from the seventh to the eighth level, and have on the seventh level an engine for hoisting the rock which is blasted out of the new shaft. He was signalled by the man in the shaft to come down to attend to some water pipes requiring his attention. He was standing by the shaft at the seventh level at the time the bucket had started to go down. It is uncertain whether he took hold of the rope to which the bucket was attached, or whether he jumped for the bucket and missed it. Unfortunately he did not signal the engineer, who was within a few feet of him, to stop the engine.

The consequence was that he fell to the bottom of the shaft, and when taken up was lifeless, his neck having been broken by the fall. Dr. McMurchy of North Bay was notified of the death, but did not deem it necessary to hold an inquest, it being evident that the accident was due to the carelessness of the man himself.

WILLIAM MARTIN'S FATAL FALL.

Death of William Martin at Copper Cliff mine.

The remaining case of accident resulting in death is that of William Martin, who on 10th December was precipitated down the same shaft in the Copper Cliff mine as that in which Axel Johnson was killed two weeks before. Deceased, with five other men was engaged in preparing this recently sunk shaft for the reception of timbers to form the division between the skip and ladder ways. For this purpose they were mounted on a scaffold made of green pole stringers, with ends pocketed in notches cut in the hanging wall, the other ends being driven wedge-shape against the foot wall. On these stringers was stretched a flooring of new pine plank. The recesses being cut in the walls for the insertion of timbers, were about breast high, or five feet above the platform. On the day of the casualty the men had completed about seventy-five feet up from the bottom of the shaft, and were engaged in cutting out notches for the reception of other timbers, when without warning a piece of rock 1 by 2 by 2 feet in size fell from the hanging wall about five feet above the platform, and breaking the plank on which Martin stood, caused him to drop through the hole thus made down the shaft and into eight feet of water at the bottom. He was taken out as quickly as possible, but died of his injuries at one o'clock of the 12th December. By direction of the Attorney-General's Department an inquest was held on his body by coroner McMurchy of North Bay, on the 13th. The following evidence was submitted, which clearly sets forth the circumstances under which the accident occurred:

Inquest by Dr. McMurchy.

THE CORONER'S INQUEST.

Murdoch Henderson.

Murdoch Henderson: I was working on the scaffold at the time. I went up to the seventh level for some tools They shouted 'fire' in the sixth level, and I called down to the men that they were firing in the sixth level and that they had better come up. The captain and Mr. Hambly came up, and the working men stayed down. I remained in the seventh level until the firing was over. I went down then. I passed under Paul Baultz, where he was working on the ladder. I went towards the hanging wall beside my partner, Herman Baultz. I was standing under the shelter of the wall. Martin was on one end of the plank and Herman Baultz and I were standing near by, on the same plank. Martin said, 'I am afraid three of us are too many on this one plank.' I tried the plank by springing on it, and I moved off towards the foot wall. I thought the plank was strong enough to support three. Sometimes a piece of rock falls off suddenly without warning. I saw the rock fall; it fell about five minutes after the firing on the sixth level. The levels are numbered from top to bottom. I think the rock fell through the effects of hammering on the wall, at the end of the piece that fell. I noticed the rock separating. I said to the man who was pounding to look out, that the slip was opening up. We did not think that there was any large piece loose. Martin was standing on the plank, over the pole supporting the stage. He stepped back when I spoke. The rock was two feet square and 12 or 14 inches thick. I am satisfied that the company take every precaution for the safety of the men. Mr. Hambly looks after the mine, to see that it is in a safe condition for the men to work. Martin did not step off the plank. It is customary for the men to come up off the scaffold during the time of firing. If they do not come up they are taking a risk which the company does not ask them to take. The company raise no objections to their coming off.

Paul Bau'tz.

Paul Baultz: I was in the mine when William Martin was injured. I was working with deceased. We were timbering the shaft. I was about four feet higher up the shaft than deceased. I did not see deceased fall. I heard rapping on the pipe, and think some rock fell at the time. Deceased was a careful man, and I do not think that the accident was due to any carelessness on his part. I did not observe any loose rock. I do not know what he was standing on when he fell, I saw the light falling. The foreman went down to pick him up. He (the foreman) was about 30 feet away at the time. The scaffold was safe to work on. The rock in falling broke one plank of the scaffold. The rock fell about four feet before striking the scaffold. The scaffold was of two inch plank and about 15 or 16 feet in length. Only one plank was broken—a plank ten inches wide.

Henry Davis, captain.

Henry Davis, mining captain: It was about 70 or 75 feet from the bottom of the shaft where the men were working. During the two weeks that the men were working there was a possibility of this rock falling. The Government Inspector examined the shaft. I have been down the shaft scores of times and did not notice that rock. I was down every day for the last week. It is my business to examine the shaft and the progress of the work and the mine generally. If I find anything defective I report it and have it looked after. I do not think that the men were careless. I am satisfied that it was through the rock falling that the accident occurred. There were six men on the scaffold at the time. The Government Inspector visits the mines about three or four times a year. His last inspection was made in August. He has visited the mines three times during the last fifteen months. It is understood that the men are at liberty to leave their work when blasting is being done, as soon as the signal is given. I made a personal inspection of the wall at the spot where the rock fell and did not see any crack.

James McArthur, manager.

James McArthur, general manager: The work going on at Copper Cliff at present is simply development work for the purpose of putting the mine in a safe state. There has been no ore hoisting since the 15th November, and this new shaft where the accident occurred is simply in process of construction and putting the mine into a safe state for resuming work. I might say that our present work is simply a series of inspections and scalings. Before resuming work again on any of these mines I have to notify the Ontario Bureau of Mines and Mining Inspector, and we have to do the same thing on the closing down of a mine. I presume that this notification is to give the Inspector an opportunity to visit the mines before resuming operations. The blasting in the sixth level was development work. This development work we expect to go on all winter. The Government Inspector was here in May, and spent three or four days inspecting the mine.

Thomas Hambly, foreman.

Thomas Hambly: I was foreman when the accident occurred. Part of the men were working at timbering. Timbering the shaft is putting it in condition for operating the skip. The skip is the bucket. The shaft is divided into three compartments. The first is a ladder road; the other two are skip roads. At the time of the accident the men were getting ready to put in the dividing pieces. There was about seventy feet of the shaft divided. The scaffold on which the men were working was independent of the dividing timbers. At the time of the accident I was up in the drift. The scaffold was safe, and did not give way. Only one plank was broken. The plank was broken by a rock falling on it. The size of the rock was about two feet square and about one foot thick. I was not aware of any loose rock likely to cause an accident. The rock did not fall from the place where Baultz was working. Paul Baultz was working six or seven feet above the scaffold, on the ladder road, and the rock fell from about three feet below him and about three feet nearer the centre of the shaft. Wm. Martin fell about seventy or eighty feet. There was about seven or eight feet of water at the bottom of the shaft. The men were timbering and scaling at the same time. I helped to take Martin out of the water. He was unconscious at the time. We were working on the job about two weeks, night and day, there being about six or seven men on each shift.

Herman Baultz.

Herman Baultz: I was working on the scaffold when the accident happened. I did not see Martin fall, or the plank break. I had one foot partly on that plank, but was looking up and did not see the rock fall. I did not notice that that rock was loose. The foreman was in the seventh level, having left the platform a few minutes before. I think the wall was examined by the foreman or Captain Davis.

John Doney.

John Doney: I was working on the scaffold at the time of the accident. I did not think the wall was unsafe. I did not see the rock fall, as I was working with my back towards the other men. I was about the centre of the shaft, at the foot wall.

Dr. Arthur.

R. H. Arthur, M.D.: On Monday morning, the 10th inst., I was told that there was an accident in the mine. I arrived here in time to see them bring the injured man, William Martin, up from the mine. He was injured about the anterior half of the scalp. Two ribs were broken on the right side. He was never conscious from the time of the accident until his death. I examined the wounds carefully, and found no fracture of the skull, no external wound sufficient to cause death. He died about one o'clock a.m. on the 12th inst. The immediate cause of death was injury to the brain.

Verdict of the jury.

The jury found the following verdict: "That the deceased came to his death through injuries received through rock falling accidentally while in discharge of his duties on the 10th day of December, 1894, and that we find no blame is attached to the company or any of its employés. We feel that there is not a proper inspection of these mines by the Government Inspector."

The jury's peculiar conclusions.

That the jury were right in finding the cause of death to be accidental and unavoidable seems to admit of little doubt, but a perusal of the evidence will fail to show what ground they had for censuring the Inspector of Mines, or what relevancy there was in adding a rider of such a character to their verdict. The nature of the inspections by that officer of the mines of the Sudbury district was not in question at all, nor was any testimony adduced showing how carefully or how frequently these inspections were made, except in the case of the Copper Cliff. Yet the jury assumed, in the almost entire absence of evidence on the point, to say that there was not a "proper inspection of these mines" by the Inspector. It is by performances of this kind that the findings of juries are brought into disrepute. If the jury meant anything at all by this part of their verdict, they meant that a more frequent and thorough inspection of the mine might perhaps have warded off this unfortunate accident. However valuable a competent inspection may be, it is not pretended that it can ensure absolute immunity from mishap, and in this case it was stated in the evidence of Henry Davis, the mining captain, that he had been down the shaft scores of times, including every day for the week previous to the occurrence, yet without noticing the piece of rock which subsequently fell, notwithstanding that it was part of his business to examine the shaft and report anything he found to be defective. He added that he had made a personal inspection of the spot where the rock fell and did not see any crack. In face of this constant and minute examination, which in such a case must be more efficacious than the most thorough examination that any official can make, it can hardly be pretended that another visit or two in the year would have saved the life of William Martin. Indeed, the office of a mining inspector is not so much to look for tiny seams, weak planks, or loose pieces of rock, as to see that work is carried on upon a proper system, and that the prevailing conditions respecting ventilation, support of roofs and walls, shafts and ladder-ways, etc., are such as to conduce as much as possible to the health and safety of the workmen. It is the bounden duty of an inspector to call attention to any defect, however small, which may in his opinion be a source of danger to life or limb, but it is manifestly unfair to hold him responsible for an accident which does not seem to have been due to any lack of proper appliances, or to an unsafe method of working, and which the careful watchfulness exercised by the miners themselves failed to foresee or prevent. In the case of the Copper Cliff mine where this accident occurred it was shown by the evidence of Captain Davis that the Inspector had visited it three or four times during the year, and by the evidence of Mr. McArthur, the general manager, that at the time of the accident the mine was closed down for the year, and that the only work done was simply development work for the purpose of putting it in a safe state. The Inspector's own report shows that he visited the mine three times, in the months of March, August and September. In view of all these facts the attempt of the coroner's jury to censure the Inspector seems to be inexplicable from any intelligent or reasonable point of view.

Other cases of accident.

The other cases of accident, which were non-fatal in their character, do not call for special mention. The most serious was that of Thomas Trethewey, who on 6th June was working a drill on a high stope in the Murray mine, when the shell of the machine worked loose and came off, knocking him over the stope. His hip was dislocated and he sustained several bad bruises and contusions. On 15th June he was reported as making good progress towards recovery.

THE INSPECTOR'S BOOK.

New mining regulations.

With the object of rendering the work of mining inspection and the recording of information more systematic and permanent, and at the same time of affording miners and employés an opportunity of learning the Inspector's opinion of the condition of any mine or works after a visit of inspection, an Order in Council was passed on the 23rd June, 1894, at the instance of the Bureau, under section 6 of The Mines Act 1892. The order reads as follows:

1. The Inspector of Mines shall present to the superintendent, manager or mining captain of each and every working mine and mining works a book to be called the Inspector's Book, in which he shall record his visits to the mine and works, duly dated and signed, and shall set forth upon each visit thereto made by him:

(1) Extent of mining operations as shown by the number and measurement of shafts, winzes, drifts, adits, stopes, pits and open works;

(2) Machinery employed in or about the mine for drilling, hoisting, breaking, etc.;

(3) Plant for roasting, treating, milling, smelting and refining ores or metals;

(4) Condition of the mine, machinery and plant in relation to the health and safety of miners and all other employes; and

(5) Any instruction or direction authorized by The Mines Act 1892, or amending Acts, deemed necessary to further secure the health and safety of miners and other employes engaged at the mines and works.

2. The Inspector's Book shall be kept in the office of the superintendent, manager or mining captain at the mines and works, and shall be accessible to the miners and all other employes during office hours.

3. A printed copy of these regulations shall be affixed to the outside cover of the Inspector's Book, and as many copies as may be necessary shall be posted by the inspector in or about the mine and works for the information of miners and all other employes.

What it is hoped they will accomplish.

It is believed that the access which will thus be afforded miners and workmen to all memoranda made by the Inspector as to the condition of a mine or works, and to all directions which he may deem necessary to give for the better protection of the health and safety of employes, will be of material assistance in the maintenance of good working conditions. If the Inspector find anything which requires to be remedied, the employés will be put on their guard against the possible source of danger; if, on the other hand, he find everything in good order, they will perhaps be able to go about their work with a greater feeling of confidence and security. And in the event of a change in the management of a mine or mining works taking place before the Inspector's instructions can be carried out, the book will inform the succeeding manager what the condition of the mine or works calls for at his hands. In any case, the condition of a mine or other works being an all-important matter to those employed therein, it is but right that means should be provided to make them acquainted with the conclusions arrived at on the subject by the officer appointed for the purpose by the Government.

T. W. G

SECTION VIII.

SUMMER MINING SCHOOLS.

Technical instruction.

The subject of technical instruction in its various relations to the mining industry was discussed in the Report of the Commission on the Mineral Resources of Ontario, and especially in relation to the interests of prospectors and miners, mining engineers and metallurgists.[1] In their Report (p. xxiii) the Commissioners say :

Practical and and scientific instruction in mining and metallurgy.

"In order that the mineral resources of the province may be successfully and economically developed it is desirable that measures should be taken for the practical and scientific training of all who may engage in the industry. Prospectors and explorers are found to be very deficient in the kind of information which would enable them to prosecute their arduous labors to the best advantage; and your Commissioners recommend for that purpose the adoption of a scheme such as has been tried with gratifying results in the colony of New Zealand, and fully explained in Appendix L. But for the education of mining engineers and metallurgists a thorough system of instruction is called for, which can only be provided by establishing a School of Mines or enlarging the course of studies at the School of Practical Science in connection with the Provincial University. It is the opinion of your Commissioners that if the duty of providing instruction of this character devolves upon the Government the obvious plan is to take advantage of the means which are available in the University courses of study, and to make such additions of instructors and appliances as may be necessary for a thorough equipment."

The School of Practical Science.

Summer Mining Schools.

The second suggestion in the foregoing extract was quickly taken up by the Minister of Education, and a mining department is being developed in the School of Practical Science as fast as the circumstances of the country appear to call for, although not as fast as those most specially interested would desire. Additions to the staff and equipment of the School are made at frequent intervals, and before the close of the present year it will be in a position to satisfy the most urgent wants of mining men. The first suggestion however was allowed to linger in abeyance until a year ago, when an experiment upon a small scale made by the Kingston School of Mining showed not its utility merely—for that had been fully demonstrated in New Zealand—but that there was a demand for it, and that miners and prospectors would readily avail themselves of the advantages of a course of practical instruction whenever the means for it were provided. Accordingly, in the session of the Legislature in 1894, an appropriation of $2,000 was voted for the purpose of organizing Summer Mining Schools in the northern districts of the province, and the inception of the work was entrusted to the Faculty of the School of Practical Science. The following Report shows how the work of the first year has been carried out, and how the project has been received by the men whom it chiefly concerns.

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[1] See Report of the Commission, p xxiii, pp. 415-20, and pp. 513-21. The first of these references contains the recommendation by the Commissioners of the scheme adopted in New Zealand for giving practical instruction to miners; the second deals more generally with technical instruction, but emphasizes the utility of the New Zealand plan; and the third (in Appendix L of the Report) summarizes the plan from the official Reports of the New Zealand Government.

REPORT OF THE INSTRUCTORS.

School of Practical Science,
Toronto, Dec. 15, 1894.

Letter of transmission.

Dear Sir,—In accordance with instructions received from the Minister of Education, I have forwarded to you the Report of the instructors of the Summer Mining Schools for the past summer. Yours truly,

LOUIS B. STEWART, Sec'y.

A. BLUE, ESQ.,
Director Bureau of Mines.

To the Council of the School of Practical Science, Toronto:

Sirs,—We herewith have the honor to submit to you our report on the Summer Mining Schools, established by the School of Science and conducted by us during the summer of 1894.

Organization at Sudbury and Copper Cliff.

In pursuance of instructions received from the Principal to proceed to Sudbury and there to conduct Summer Schools for miners and prospectors, we left Toronto on Monday, July 1st, having previously made the necessary arrangements as to equipment, etc.

On our arrival at Sudbury we spent some time in making the acquaintance of those interested, in explaining the nature of the work and in visiting the various mines in order that all might be notified in time to take advantage of the opportunity. Those mines which we were unable to personally visit were communicated with by mail.

It was finally decided to hold classes both at Copper Cliff and Sudbury, as this arrangement was found to be most convenient for all concerned.

In Sudbury the use of the public schoolhouse was obtained through the courtesy of the school board, and it proved eminently suitable for the purpose. At Copper Cliff we were granted the use of the band-room, which, although not as suitable as could be desired, answered the purpose fairly.

The classes were held in Sudbury on Mondays, Wednesdays and Fridays at 7 p.m.; and at Copper Cliff, as the men are divided into day and night shifts, it was found necessary to hold classes in the afternoon at 3 o'clock and in the evening at 7 o'clock on Tuesdays, Thursdays and Saturdays, thus giving both shifts an opportunity of attending.

The classes were opened on Monday, July 9th, and were continued regularly until August 15th.

Organization at Rat Portage.

While at Sudbury we received instructions from the Principal to proceed to Rat Portage and there to continue the classes.

In compliance with these instructions we left Sudbury on August 16th and opened the class at Rat Portage on Monday, August 20th. At Rat Portage we were materially assisted by the committee previously formed there in connection with this work. We were offered the use of the schoolhouse in which to conduct our classes, but owing to the fact that the school was about to reopen it was found advisable to engage a hall for our purpose.

The classes here were held on Tuesdays, Wednesdays, Thursdays and Fridays at 7 p.m., as a large proportion of the men found it impossible to attend more frequently. Afternoon classes were established later on for the benefit of those who were unable to attend at the beginning.

The work was discontinued on Friday, September 21st, and we arrived in Toronto on Tuesday, September 25th.

Lectures on subjects of the course.

The use of text books was not advocated until the classes had obtained a fair idea of the subjects taken up, and then certain works were recommended for those who desired to further advance themselves in the work. The classes were advised however to make careful notes on the practical work and lectures. For the purpose of illustration where blackboards were not available, large sheets of blank paper and colored chalks were employed, and served admirably for the purpose. The course of instruction was made to embrace the following subjects :

Geology, including mining geology and ore deposits.
Mineralogy, including practical work with the blowpipe for the identification of minerals.
Lithology, with special reference to the rocks of the region.

It was intended in the beginning to deliver lectures on elementary chemistry and to illustrate them with experiments; but for want of time these lectures were abandoned. Some instruction however in elementary chemistry bearing directly on mineralogy, geology and blowpipe reactions were given during the course.

The practical work and instruction in the subjects taken up was made to bear more or less directly on the region where the class was held, thus adding a special local interest.

Cost of the course to students limited to the blowpipe outfit.

No fee was exacted for instruction, but a small sum ($2.50) was charged for a blowpipe outfit which became the property of the student. This arrangement was found necessary, as the practical work could not be carried on without these appliances and as it was impossible for the men to obtain them in time. These blowpipe kits were designed especially for the work, and contained everything necessary for the ordinary blowpipe operations. The expense of these outfits was covered by the amount charged for them.

At Rat Portage the number of kits was found to be insufficient, and some additional appliances were ordered for those not already supplied, one dollar being charged for the use of these.

A collection of typical rocks and minerals was taken for the purpose of illustration ; also a supply of the various reagents required for blowpipe work.

Manner of treating the subjects of the course.

The time was so divided that about one-half of each meeting was devoted to practical work and the other half to lectures. The subjects previously mentioned were treated in the following manner :

Geology.—(*a*) Historical Geology. An account was given of the origin of the earth and a synopsis of the formation of the primary rocks, reference being made to their economic importance and local development. This was followed by a description of the stratified deposits, and their geological sequence explained and graphically represented.

(*b*) Dynamical and Chemical Geology. The different rock and mineral forming agencies were briefly considered; the growth and subsequent alteration in the various rock deposits were noted, especial attention being directed to such phenomena as are of importance to miners and prospectors.

Lithology.—The various classes of rocks were considered regarding their appearance in the field, their economic importance and other points. Volcanic and metamorphic effects on the local rocks were especially mentioned. Hand specimens of the various rocks were exhibited and some microscopic sections also shown.

Local Geology.—Under this head special instruction of local importance was given.

Mining Geology.—This subject was thoroughly expanded owing to its great economic value. The nature, mode of occurrence, value, etc., of the various minerals and gangues were thoroughly explained. In Sudbury especial attention was directed to nickel deposits, and at Rat Portage to the nature and occurrence of auriferous matter. Methods of estimating the value of mineral deposits and of reporting on mineral lands were thoroughly explained.

Mineralogy.—The lectures on mineralogy were made to bear directly on the economic minerals occurring or likely to occur in Canada and the province of Ontario, and treated fully their properties, uses and methods of detection.

To give the lectures a more practical bearing, it was deemed advisable to treat all the minerals taken up as ores of the more important metals and other economic products.

The general physical characters of minerals, such as form, hardness, color, streak, cleavage and fracture, were first considered, and the use of these characteristics in determining minerals carefully explained.

This was followed by a systematic treatment of the minerals of economic value, including those which occur in association with economic minerals and are classed as gangue minerals. These gangue minerals though of small commercial value in themselves were taken up in detail, for a knowledge of them was shown to be of great importance to the prospector on account of their association with the economic minerals occurring in the various ore deposits.

Special stress was laid on the value of field tests; and the use of the magnetized knife, the lens, and other simple appliances was taught.

The lectures throughout were well illustrated, Canadian minerals, as far as possible, being used for the purpose.

Practical instruction with the blowpipe.

In the practical portion of the work the ordinary blowpipe tests for the common metals and other elements occurring in minerals were explained, and the students made to perform the operations for themselves. This was followed by the especial application of blowpipe tests for the identification of the useful minerals themselves. The qualitative blowpipe assay for silver in galena was thoroughly taught, as the prospector who is acquainted with the process can decide in the field whether a galena is argentiferous or not, and thus save time and expense.

Occupation of men in the classes.

The men attending these classes were largely prospectors, miners and furnace or mill-men, mine owners and others more or less directly interested in the industry.

Number attending at Sudbury,

The number of students in regular attendance at Sudbury was eight, all of whom took both practical work and lectures.

at Copper Cliff,

At Copper Cliff the class numbered nineteen regularly enrolled students, taking both departments of the work.

and at Rat Portage.

The Rat Portage class numbered twenty-four, the majority of whom attended both lectures and practical work.

In addition to the numbers given above many others both at Sudbury and at Rat Portage attended the lectures from time to time.

Interest of students and the public in the work of instruction.

In closing we wish to express our high admiration of the intelligence and perseverance exhibited throughout the course by those attending. A live interest in the progress of the work was shown by the mining community at large, and many evidences of appreciation were evinced.

The opinion was expressed that these Summer Schools were a step in the right direction, and that much benefit to the mining industry would accrue from their continuation.

The want of practical instruction in matters of this kind had been long felt by the prospectors themselves, as the majority of them have neither the inclination nor the means to attend established schools of mining at distant places.

Although this, your first venture of the kind, has met with eminent success, we feel that that success would be still greater and the attendance largely increased if the classes were opened earlier in the spring.

Thanks for facilities afforded.

We cannot close without expressing our hearty thanks for the numerous courtesies extended to us by those with whom we were brought in contact. Especially are our thanks due to James Weidman, editor of the Record and secretary of the committee of organization formed at Rat Portage; also to the firm of Williams Bros. & Grey for the loan of samples of local minerals. To these and to others at Rat Portage we feel deeply indebted for facilities afforded us of becoming better acquainted with the region. At Sudbury we especially wish to thank James A. Orr, editor of the Sudbury Journal, the members of the school board and James McArthur, Esq., manager of the Canadian Copper Company's works.

Judging from the experience of the past summer and from the fact that many, in addition to this year's students, have already expressed the intention to take advantage of the opportunity were it again presented to them, the advisability of continuing these schools is undoubted.

Evidences of appreciation.

As an evidence of the appreciation shown for the work, we may state that at Sudbury and at Copper Cliff flattering resolutions of thanks were tendered us, and at Rat Portage we received a highly complimentary address expressive of thanks and appreciation of the efforts of the School of Science, of the Ontario Government, and of ourselves to further the cause of mining education and of the mineral industry in the province of Ontario.

We have the honor to be,
Yours very respectfully,
W. E. BOUSTEAD,
W. A. PARKS.

School of Practical Science,
November 5, 1894.

MINING SCHOOLS IN NEW ZEALAND.

Principal and minor schools for technical instruction.

In New Zealand a steadily growing interest is maintained by the Government in providing technical instruction for the benefit of miners. Schools are maintained at Dunedin, Reefton and the Thames, where liberal courses are provided; and there are besides a number of smaller schools where an instructor attends occasionally, and where advanced students and gentlemen who take an interest in technical education give instruction and lectures. In his report on the goldfields of New Zealand for last year to the Minister of Mines, the Inspecting Engineer argues that in the pursuit of his avocation no ordinary degree of training is required by the miner. "To be able to successfully carry on mining operations in all its branches," he says, "a man must not only have a large practical experience in actual workings of mines, but he also must have a general knowledge of the chemistry of metals in order that he may analyze and ascertain the percentage of metals the ore contains; he must have a knowledge of mineralogy before he can identify the form and crystallization of the various mineral ores; a knowledge of geology, to be acquainted with faults, slides and heaves, to be able to determine the method of again discovering lodes which may be cut off and displaced by fault-movements, and to have a knowledge of the composition of the country rocks in which the minerals are found; . . . a knowledge of metallurgy, so as to be able to fully understand the best and most economic methods of extracting the various metals from the ores; and he also must have a fair knowledge of mathematics before he can understand the principle of and carry out underground surveys." From these points of view it will be seen that whoever adopts mining as an occupation requires a technical education as large and varied as that of almost any other profession.

Their utility.

Thames school.

At the Thames school in 1893 the average number of students was 91, of whom 40 were registered, and 51 attended the Saturday science lectures. The Director of the school reports that during the past four years 23 of the students have obtained employment in various capacities connected with mining, 10 as mine managers at salaries ranging from £200 to £350 a year, 6 as metallurgists in reduction works where the Cassel cyanide process is in use, from £125 to £200, and 7 as metallurgical assayers from £120 to £150. Since the beginning of 1890, 24 students have been prepared for the government examination of mine managers, of whom 21 have secured first-class certificates.

Reefton school.

The Reefton school shows a decreasing attendance, which is attributed to the repeated breaking up of the classes, occasioned by the Director's attending smaller schools in the outlying districts. "These short visits," he states, "which are of no practical value to the students, have seriously interfered with the Reefton school, which last year showed that good, sound and practical work was being done. The efficiency of this school," he adds, "can never be maintained unless the classes are carried on for at least nine months during the year without interruption. A month's instruction could then be given to two or three of the other schools, which would no doubt be of some value in keeping them together. In addition to the Reefton school the Director has given lectures and instruction to six other classes in various parts of the district.

Otago school.

The Otago School of Mines is attached to the University of Dunedin, and is doing good work. Nineteen students were in attendance during the session of 1893.

Minor schools.

The minor schools are nine in number, some of which are largely attended, but it does not appear that reports of the work done at them is made to the Government.

Cost of erection and maintenance.

The expenditure by the Government on Schools of Mines since their inauguration (in the nine financial years 1885-6 to 1893-4) exclusive of subsidies paid to the University of Otago, has been £12,895. For subsidies towards the erection and maintenance of schools of mines there has been paid £1,604; for chemicals, apparatus and mineralogical specimens supplied to schools, £942; and for salaries of teachers, travelling expenses, etc., £10,348. For maintenance of the school attached to Otago University an additional sum of £4,250 has been paid; and the total expenditure of 1893-4 was £1,556.

Success of the schools.

"Those engaged in mining pursuits," the Mining Inspector says in his report to the Minister, "fully appreciate the advantages of a technical education at these institutions, and many avail themselves of the opportunity afforded of acquiring a theoretical knowledge of subjects connected with working of mines and treatment of ores, of which several of them have had many years' practical experience; and it is from such class of men that we may expect to find our future mine managers. The time has gone by when everything was done by the rule of thumb. Mines are now worked to much greater depths than in former years, and ores which a few years ago were considered valueless are now worked at a profit. On all the principal goldfields there are now men who can test and ascertain the value of ores met with, and this can be justily attributed to the establishment of the Schools of Mines."[1]

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[1] New Zealand Papers and Reports relating to Minerals and Mining, 1894, p. 21C3.

FIFTH REPORT OF

THE INSPECTOR OF MINES.

REPORT OF THE INSPECTOR.

To THE DIRECTOR OF THE BUREAU OF MINES:

SIR,—I have the honor to transmit to you my fifth Annual Report on the Inspection of Mines for the province of Ontario, being for the year 1894.

The general outlook.

There has been no revival of work in the silver mines, as the market value of silver has been below the cost of its production in this province. Several of the large producing mines west of Fort Arthur are in a condition of comparative readiness for operation whenever the product can be placed upon the market at former prices. The same conditions exist in connection with the phosphate and mica properties in the eastern part of the province. Work has been entirely suspended on these mines throughout the year, though they stand in readiness to yield their full quota of returns when markets improve. The iron mines have also been idle.

Suspension of operations in silver, iron and phosphate mines.

Activity in prospecting for gold.

As will be shown by the report, there has been a marked improvement in prospecting for and in the development of gold properties, especially in the western portion of the province. The coming year apparently will be one of unusual activity in the production of the precious metal. Many new discoveries extending over a wide area have been made, and the extensive preparations for active operations both in mining and milling the ores will no doubt place this department of our mining industry on a much broader basis than it has ever attained before. This activity is the more encouraging from the fact that gold values never fluctuate to any appreciable extent, nor is the market liable to be overstocked. We may look for a permanency in gold mining which may be denied to almost every other class of minerals.

Copper and nickel.

The older copper and nickel mines in the region of Sudbury have been largely operated during the year, with the usual favorable returns, and as greater depth has been reached in some of them, especially in the Copper Cliff, with an excellent showing of ore, assurance is given that the large ore bodies exposed will not soon become exhausted.

GOLD.

Sultana Mine.

The Sultana island upon which Sultana mine is situated comprises 450 acres. For description see former report of the Director. On the 26th of July, the date of my visit, the main shaft of the mine, 7 by 14 feet, had reached a depth of 150 feet from the surface. At 66 feet from the surface No. 1 level was driven north 72 feet 4 in., stoping back 6,000 cubic feet; to the south it has been driven 62 feet 3 in., stoping 3,000 cubic feet. No. 2 level is 132 feet from surface, and was driven north 18 feet 6 in. and south 7 feet 6 in. Below No. 2 level the shaft was sunk 18 feet. At this date work was confined to drifting and sinking in the bottom level, sinking a

Extent of workings on the property.

winze in the bottom of No. 1 level 50 feet north of the shaft, and stopi back of No. 1 level north. North of the main shaft 150 feet a perpendicul shaft was sunk away from the vein to the depth of 45 feet. South of t main shaft 132 feet a shaft was sunk on the vein to the depth of 40 fee having a dip west 81 degrees. At the distance of 285 feet south of the mai shaft and on vein No. 3 a shaft was sunk 45 feet. None of these outsid shafts have been worked for the past three years. The work in the min was under the supervision of Captain Z. J. S. Williams, and was done in neat and substantial manner, with due regard to the safety of the workme with the exception of walling off the ladderway from the part of the sha used for hoisting ore, which I directed should be done. About 20 tons o ore was being lifted daily by the use of a small engine and conveyed to th mill, a distance of 250 feet.

Machinery and mill.

The machinery at the mine consists of a small double cylinder hoist 15 h.p , boiler 40 h.p.., air compressor 40 h.p., air receiver for Rand drills and two force pumps, one for feeding the boiler and one for pumping water out of the mine. For complete description of mill and equipment see pp. 18-19 of the Director's report of 1893. At the time of my inspection, the whole of the outfit was in good running order and doing excellent work. Suitable guards, however, were required to be placed around some parts of the machinery as a protection to the men, to which I called the attention of Captain Williams, who also had the supervision of the mill work. He stated that it would be immediately done. The mill has capacity for treating from 20 to 30 tons daily. About six cords of wood are consumed daily.

Report of progress by the mining captain.

In a recent communication from Capt. Williams he states : "The main shaft has been sunk to the total depth of 175 feet ; the vein continues strong and well defined, now 4 feet wide, yielding a good grade of ore. The No. 1 level has not been continued. The No. 2 level has been extended north 40 feet and south 121 feet. A winze has been sunk in the bottom of No. 1 level north of the shaft to good pay ore. A raising stope' has been put up from No. 2 level north to connect with the winze ; this has opened out good ground. A good stope has also been opened in the back of No. 2 level south of the main shaft. Work in the main shaft has been suspended for some time, but it is now being sunk again. All the work ordered by you when at the Sultana has been done ; the shaft has been divided and cased up between the ladder way and hoisting shaft and guards placed around machinery. Considerable stoping has been done on No. 3 vein off the shaft at the back of the mill. This vein is from 3 to 5 feet wide and yields good grade ore. There has been no additional machinery put in since you were here except one Rand drill, making three in constant use. The mill has been running regularly about 15 hours per day, and very satisfactory results obtained."

Employés.

A total force of 41 men were employed, 5 of whom are mill men, 24 on underground work and the remainder on work outside.

Buildings.

The buildings in connection with the mine are : Stamp mill, 130 by 75 feet ; smith shop, 25 by 20 ; office, 30 by 20 ; assay office, 28 by 18 ; boarding house, 60 by 25 ; sleeping camp, 16 by 12 ; stable, 20 by 12 ; dock frontage.

135 feet. The magazine, 12 by 14 feet, is situated 500 feet distant from other buildings.

A small boat is used for transit to and from the mine to carry supplies, etc. in summer, and sleighs are used on the ice in winter.

Mr. John F. Caldwell of Winnipeg, the owner, spends most of his time at the mine, Captain Z. J. S. Williams has charge of the work in the mine and mill, and Mr. J. R. Bell is assayer.

Other properties.

Capt. Williams has kindly favored me with the description of the following properties, none of which were being worked at the date of my visit:

"The King mine, near Pine Portage mine, is owned by Mr. Kennedy. Here a tunnel is being run into the hill to intersect the vein at a depth of 76 feet from surface; this tunnel is now in 60 feet and they expect to intersect the vein in the next 10 feet.

"A property adjoining the Treasure mine near Rossland is being developed by Mr. Halstead of Chatham representing a Detroit syndicate. Here they have two shafts, one down 45 feet and the other 40 feet. This property looks well, and in all propability a ten-head stamp mill will be placed early in spring.

"Regina mine on White fish bay has been purchased by an English company. They have a shaft down 19 feet. Plans have been made for a ten-head stamp mill, which they intend erecting early this spring.

"Mr J. F. Torrance of Montreal has been doing some developement work on the Morris locations, also near Rossland, for a Montreal syndicate. Several trial tests have been made on different veins with very satisfactory results."

Captain Williams also states that there are several shafts being opened on different locations in the Rainy Lake district, and it is reported that three stamp mills are now being erected, and that several more will go in early this spring.

Properties on the Seine river.

When at Port Arthur, July 30th, Colonel W. S. Ray, a banker, informed me that he had purchased a three-eighths interest in a property 34 miles east of Fort Francis, a quarter of a mile from Shoal lake and near the mouth of Seine river where it enters Rainy lake, known as A.L. 75, 40 acres. Mr. John Green of Fort William has an eighth interest, and Thomas Wiegand a miner, and the discoverer of the property, holds the remainder. Mr. Wiegand had recently taken up with the same parties A.L. 74, 41 acres and A.L. 76, 108 acres, all held by deed. The discovery of gold on A.L. 75 was made last spring and a shaft 6 by 7 feet was sunk to the depth of 12 feet, which was then filled with water. Prospecting was being done on other properties in the same region which had not been definitely located. Mr. Wiegand had left Port Arthur the Tuesday previous with a surveyor to locate five other properties. At this date other prospecting for gold had extended up Seine river as far as Shoal lake and beyond; Mr. Ray stated that they had done more work than any other party. Parties could go by tug direct from Fort Francis to the locations, and 12 miles beyond.

Colonel Ray states in a recent letter that the properties now owned by him on Seine river are embraced in eleven locations with an aggregate area of 689 acres. Parcel AL75 has been purchased by Mr. J. C. Foley of Duluth for $12,000. A considerable amount of developement had been done on it previous to the transfer of ownership. Mr. Foley has let a contract to sink a shaft 100 feet and the results are looked for with much interest. Prospecting throughout the winter will be continued on several other of Mr. Ray's properities, and already a large number of veins have been exposed. On AL94 one shaft is sunk to the depth of 19 feet and another 7 feet. From these openings assays have been made showing $109, $110 and $120 per ton of gold, with from 80 cents to $3 in silver. At the date of his writing work was being done on a well mineralized vein of 7 feet width on A.L. 74. The great necessity at present is a road from the Canadian Pacific Railway to the Seine river. Mr. Ray suggests that Raleigh station would be a good starting point, and if a trail 8 feet wide were cut out it could be utilized for a winter road; there is a fair canoe route which could be used in summer. At present people prefer going via Duluth instead of by Fort Frances. This is notonly diverting trade from our own province, but keeping explorers away.

Location AL75.

It will be of interest to note an official report made of the pioneer mine in this district by H. V. Winchell, M.E., of the Geological Survey of Minnesota, as late as November 15th, 1894. It was made to Col. Ray, as follows:

Winchell's report on the property.

"I take pleasure in handing you the following report on location AL75. Although I had no thought of making a report of this nature at the time I visited the property, and my report is for that reason incomplete in some respects, yet I found so much of interest there, and was so agreeably surprised with the showing already made, that I instituted quite a careful examination of the veins thus far uncovered, and of the geology of the immediate vicinity so far as it bears on the question of the probable richness and depth of the quartz veins.

"AL75 is a mining location taken under the laws of Ontario, and comprises about 40 acres. It is situated about one-fourth of a mile north of Shoal lake, which is merely an expansion of the Seine river, and about six miles east of Rainy lake.

"The estimated elevation of AL75 is from 40 feet to 60 feet above Shoal lake. There is an abundance of timber for mining purposes on the location and its vicinity. Water is plentiful close by, either in the lake or in small streams which flow into it.

"The region in general is embraced within the great area of Archean rocks which lies north and west of lake Superior, and is marked Laurentian and Huronian by the Canadian geologists.

"The rocks are of three principal varieties: 1, granite or gneiss. 2, crystalline schist; and 3, semi-crystalline or earthy green schists and slates. There are also in some localities dykes of trap rock and areas of eruptive granite and gabbro. The presence of the latter (eruptive rocks) has an important bearing upon the character of the quartz veins and will be discussed later.

"The strike of the rocks varies locally, but is prevailingly in an east-west or northeast or southwest direction.

"AL75 is largely if not entirely within one of these eruptive granite areas. This rock is not really granite, speaking from the mineralogist's standpoint, being composed largely of course grains of quartz enclosed in a grayish green hydrous-magnesian silicate like talc or serpentine. But it has the general aspect of granite, and is so marked on the geological map of the Canadian survey. On the north side of this granite or prolodyte as it may be called is an area of eruptive rock called gabbro by Dr. Lawson. It is a very old and much altered eruptive, but probably more recent than the granite. On the south side of A.L. 75 is a belt of eruptive greenstone, and still further south and southeast are found the sedimentary slates and schists lying unconformably on the granite.

"There appear to be two distinct classes of quartz veins in this region, and both classes are now being taken up and developed for mining purposes. The second class of veins cuts across the strike of the rocks, and hence has a general northerly trend. These veins are quite uniform in width, or at least do not change so suddenly as those of the first class, and have the appearance of true fissures. Some of them can be traced for a mile or more by outcroppings, and the walls are usually free or separated from the vein rock by a selvage and considerably slickensided. They occur in the granite and gabbro region and are occasionally quite heavily charged with galena, zinc-blende, pyrite, chalcopyrite, argentite (sulphide of silver) and visible gold. To this class of veins belong the veins on A.L. 75. Their dip is nearly vertical, or at a high angle to the east. Discovered by Thomas Wiegand, in September, 1893, considerable exploring was done during the summer of 1894, and at the time of my visit in October several different veins had been uncovered and traced for a considerable distance on the location, and test pits had been sunk on two of them.

"Pit No. 1, at the time I saw it, was 12 feet deep on the vein. Its width on the surface was about six inches, but at the bottom of the pit it had widened to about two feet. So far as opened up the vein was equally mineralized throughout its width. Some small stringers coming in from the walls contained visible gold. Just west of No. 1 about 75 feet is a vein three feet wide on which no prospecting has been done. The ore has a similar appearance to that in the other veins on the property. A sample taken of the ore thrown out of No. 1 pit, in which no gold could be seen, assayed $6.83 in gold and 15 cents in silver, a total of $6.98 per ton.

"Pit No. 2 on the west vein is about 150 feet from the west line of the location. This vein strikes north-south and dips east about 80 degrees. Its width, as shown in the 19-foot test pit, varied from one to three and a half feet. It is heavily charged with blende, pyrite and galena, and contains some chalcopyrite and black silver. Streaks and lumps of solid pyrite are found in it which show a good per cent. of gold on being crushed and washed in a pan. A sample taken to represent the average of the dump at this pit yielded $7.25 in gold and $1.55 in silver, or a total of $8.80. Another sample taken across the vein near the surface assayed $66.86 in gold and 30 cents in silver, a total of $67.16 per ton.

"Another vein was seen on this location; it was about a foot wide and showed native gold on the surface when the moss was pulled off. No work has been done on this vein, and no sample was taken. All of these veins have good walls so far as they could be seen, and lead in a straight course across the location, cutting through the granite.

"It is a fact well known to economic geologists that the richest gold mines in the world are in the vicinity of eruptive rocks. It is now generally believed that the presence or absence of gold in quartz veins depends largely upon the presence or absence of heated solutions in circulation in these veins and the neighboring rocks at the time the veins were formed. These heated solutions are always active in volcanic regions, and in proximity to subterranean lava flows or masses. Where a new region is opened up therefore the first question to be settled is, are there any eruptive rocks there? If this question were asked regarding A.L. 75 an affirmative answer would be emphatically given, for, as we have seen, there is the granite supposed to be eruptive, there is the grabbro north of the granite, and there is the greenstone south of it; most decidedly a region of eruptive activity.

"The only conclusion that can be drawn from the foregoing statement of facts concerning the geology of this vicinity and the veins on this location, together with the result of the samples taken, is that it is a most promising prospect. The veins widen as depth is attained, and the ore is rich enough so far as the pits have been sunk to pay a handsome profit over the expense of mining and treating it."

On Bad Vermilion bay.

Other discoveries of much promise have been made, notably a property said to have been purchased recently by George H. Hillyer and Hugh Steel of the Russell Miller Mining Co., situated three-quarters of a mile east of the Bad Vermilion bay, on which a shaft has been sunk over 30 feet in depth with a well defined vein showing rich free gold.

The mining laws.

Concerning the mining laws the Duluth Herald says: "There is one thing that should be remedied immediately, for it militates greatly against the American side of the basin. That is the difficulty in obtaining title to mining claims. As soon as a man finds a claim he is met by a contest from some man who has made a timber and stone filing on his land, though he has never been within 150 miles of it. In Ontario the task of taking a mining claim is a very simple one, and the consequence will be that unless the matter is remedied the entire body of prospectors and developers will be driven to the Canadian side."

A large gold-bearing area to be prospected.

Mr. Peter McKellar of Fort William in a recent letter states that explorers have been busy during the past year between Fort William and Lake of the Woods, and many discoveries of free gold have been made, more especially in the vicinity of Savanne station, Eagle lake, Wabigoon lake, Manitou lake, Rainy lake, Shoal lake and Seine river. A test was made by Mr. McKellar last fall of 500 lb. of surface quartz taken from a late discovery made at Wabigoon lake by running it through the McKellar pulverizer. The button of gold from the amalgam saved weighs three grammes, value about $2. This was the first trial on gold with the machine. The tailings would still hold the greater portion of the gold, and were saved for further treatment. The test demonstrated the fact that the ore is an excellent milling ore, and if found in quantities the property is of much value. "It is the general impression of mining men here," adds Mr. McKellar, "that as the gold-bearing schist formation between Lake of the Woods and Thunder Bay district shows numerous veins and deposits of quartz, many of which have been proven to carry free gold, lively times will be witnessed the coming summer in prospecting and mining for gold throughout those localities."

A discovery near the Port Arthur, Duluth and Western Railway.

A gold property has been discovered one mile north of Lee Blain station on the Port Arthur, Duluth and Western Railway, and three miles east of the boundary line. The discovery was made in the fall of 1893 by Albert Quirt. Work in prospecting the property began in June last by sinking a shaft 6 by 6 feet to the depth of 22 feet, which was well protected by timbering. A well defined vein of 2½ feet width has been followed, having a steep dip towards the north. The hanging wall is slate and the foot wall granite. Mr. Hille of Port Arthur states that the gangue consists of copper and iron pyrites, a little zinc-blende, lead, quartz and calcite. Assays which he made ran as high as $12 in gold. Mr. Broult, who gave to me the description of the location, has charge of the Customs office (American side) at the boundary line, the terminus of the railway.

Ophir Mine.

The Ophir gold mine is situated 16 miles north of Bruce Mines station on the Canadian Pacific Railway, Sault Ste. Marie branch, and on lot 12 in the 3rd concession of the township of Galbraith, district of Algoma. The inspection of this property was made the previous year by the Director of the Bureau, and a complete description of it was given in his annual report of last year. My first visit (March 9th, 1894) was on the occasion of an accident which occurred on the 5th March by the falling of a small fold of rock from the hanging wall, which killed three men and slightly injured two others, upon which I made a special report to the Commissioner of Crown Lands. Work at the mine was temporarily suspended at the time pending the investigation of the accident. The mine had been worked at first from the surface of the hill and three openings were made following the chimney of ore down to the depth of 25 or 30 feet with a dip of 45 degrees. Work was then extended lengthwise on the vein to a distance of 180 feet, slightly rising as the work advanced. A rock roof except at openings was left from 12 to 15 feet in thickness. The width between the foot and hanging walls is about 20 feet. The more recent workings began at the face of the hill some 20 feet below the upper workings; an adit was driven in on the vein, and as the work advanced the entire body of ore was stoped out between the walls to the upper drift. This drift was continued to the distance of 105 feet from the entrance. At 30 feet from the mouth barren rock was encountered, a portion of which was left standing for support to the hanging wall, the only pillar left for the entire distance. The width of the vein averaged 12 feet and about 35 tons were being removed daily, which carried from $5 to $6 per ton. A short distance from the mouth of the drift, at the base of the escarpment, a perpendicular shaft had been sunk to the depth of

Extent of the workings.

about 100 feet; also at the mouth of the drift an incline shaft had been sunk with a view to intersect the former one, but the connection was not made. Both were filled with water. Twenty-three men were usually employed at the mine and on outside work, and 9 in the mill, making in all a force of 32 men.

The mill.

The mill, which is about 40 tons capacity in 24 hours, was running and the machinery was in good order. About four cords of wood were consumed daily at the mill and at the pump house at lake Ickta from which the water is supplied for both mill and mine.

Unsafe condition of the mine.

The mine was not in a satisfactory condition, and I considered it necessary to give to the general manager the following written notice for its safe protection: "Before any further work is done on the floor of the drift in the mine I direct that substantial supports be placed in the mine, by placing upright stulls or timbers under the roofing and also against the hanging wall, with flagging overhead sufficient in number and strength to prevent any further cleavage of rock by action of frost or otherwise. Also, at the point indicated to-day for driving in a tunnel, leave standing a pillar of ore of not less than 15 or 20 feet in width before raising to the opening above, and as the tunnel or working is continued on the ore vein leave pillars sufficient in number and strength to support the hanging wall. Have the surface openings over the present underground workings properly fenced. Also put side railings on the tramway leading from the mine to the mill for such a distance out from the latter as may be necessary to protect from danger while working on it—perhaps as far out as where the tree fell across it."

The manager, Mr. Owen, discontinued his connection with the mine early in May, and Mr. Francis D. Taylor, M.E., of Brockville, who has spent many years in managing mining property, was appointed by the company to superintend the work. Soon after his appointment the following letter was received, dated 17th July:

> Dear Sir,—Having been recently appointed superintendent of the Ophir mine by the Company, my attention has been called to certain instructions given by you to the said Company in a letter bearing date March 9th, 1894. In the first place, that in the event of carrying a drift easterly of the point where the accident occurred "a pillar was to be cut off and left of not less than twenty feet." Now as the vein matter has been tested in an easterly direction by drift for 120 feet more or less, the vein has not yielded in gold so satisfactorily as expected, and I desire to know if you will allow me to take out the ore by way of "stoping" between the level in question and the upper level or drift for twenty-five or thirty feet. I shall see and take every precaution to have the work well timbered and properly secured, so that no accident shall occur. You will please understand that the roof from the present entrance of this drift up to the point in question is carried safely and securely by strong stull timbers, and I am asking that you grant us the privilege of extension of this timbering from twenty to twenty-five feet further in same drift. I have given orders that the wishes expressed by you with regard to putting up a railing on the tramway leading from mill to mine be at once attended to. Also that the surface openings referred to be properly fenced off. Your acquiescence and a prompt reply will oblige yours most respectfully.
>
> (Sgd.) Francis D. Taylor, M.E.
>
> P. S.—Since you were here I have made complete plans, sections and cross-sections of the mine, and am keeping them up.

I complied with the superintendent's wishes, and at my next inspection found that the work had been done safely.

The second inspection.

Early in August I again inspected the mine. The work was in a much improved condition under the supervision of Mr. Taylor. Twenty men were employed at the mine and in the mill. The mine was well secured by stull timbering and flagging over the workings. The extent of stopes was 38,760 cubic feet, and the drift was 166 feet beyond the stopes in barren ground. One shaft had been sunk to the vertical depth of 78 feet and the stope shaft was 66 feet in depth at a dip of 60 degrees south. No work was being done in either of them. No machinery was used in the mine, the drilling being done by hand. There is a tramway track from the floor of the level with a slight down grade over the trestle work to the upper part of the mill, over which the ore was trammed by hand from the mine to the mill, a distance of 411 feet. The stamps and feeders, a No. 5 Blake crusher, as well as the other machinery, are supplied with power by two boilers of 120 h.p. and an engine of 75 h.p. The eight Frue vanners with tables and cleaning-up pans were in good working order. The 4-inch discharge pump in the pump house at the lake was doing its work efficiently. The work both in mine and mill was being conducted with care, and in every part regard was paid to the safety of the workmen.

The outfit of buildings besides the mill is as follows: The manager's dwelling, cook house and dining room, mining bunks for mill and mining men, office, assay office, store, blacksmith shop, magazine, ice house, root house and stabling. All are conveniently arranged and neatly kept.

Creighton Mine.

The Creighton property was operated to a limited extent in the early part of the year, when work was suspended with the exception of test borings, which gave favorable results. For a full description of the property see Director's report for 1893. In August, when at Sudbury, Mr. J. R. Gordon, the manager, stated to me that work would again be resumed at a not distant date. Recently the following interesting communication from Sudbury was made to the Globe of Toronto: "It is understood here that the Creighton Gold Mining Company are about to start active operations again on their property, some twenty miles west of here. After the mine closed down an expert mining engineer advised exploring with a diamond drill some 400 yards west of the shaft, and at a depth of about 200 feet a vein of quartz was struck indicating a total width of over 20 feet and showing several very rich specimens of free gold. It is understood that a meeting of the directors has been held at Ottawa and action taken to prove conclusively the extent of the ore body. Gold mining has been inactive in this locality recently, and it is thought that this discovery will arouse interest among owners of properties in the Vermilion river valley, as it is thought that the same vein which runs through the Creighton property extends throughout the whole valley."

Exploratory work with a diamond drill.

Bonanza Mine.

The Bonanza gold mine is on lot 2, concession 4, township of McLennan, near lake Wahnapitae. A vertical shaft in this mine has been sunk to the depth of 50 feet and timbered for 30 feet through the broken formation. A drift has been run in on the vein 40 feet. A horse whim and pulsometer pump were used at the mine. I am indebted to Mr. Thomas Clemens, who did the developement work on the property, for the foregoing description.

At that time (August 8th) work was suspended and the shaft filled with water. The property is owned by Berlin capitalists. The following extract is taken from the Toronto Globe of recent date: "The Bonanza Nickel Mining Company is engaged in developing a vein of gold on the shore of lake Wahnapitae, in the Nipissing district. The vein has a surface length of 1,600 feet, and a test assay gave returns of $100 a ton. A ton of the ore has been taken out and will be sent to the School of Mining at Kingston for thorough test."

Ledyard Mine.

The Ledyard mine is situated a short distance from the southeast corner of the east half of lot No. 19, in the first concession of Belmont township, county of Peterborough, 100 acres.

The property is owned by the Ledyard Gold Mine Company (Limited), with a capital stock of $1,000,000 in shares of $10 each; $150,000 reserved for working capital. President, T. D. Ledyard, Toronto; vice-president, T. H. Yeoman, Toronto; secretary-treasurer, T. H. Yeoman, Toronto; counsel, Charles Henderson, Toronto; mine address, Wariston P. O.

At the time of my inspection, July 12th, Mr. Fred. Straith Miller had the superintendence of the work. He stated that his experience in mining and engineering had stretched over a period of 40 years, 15 of which had been spent in Germany, 3 in Wales, and since 1872, when he came to Canada, he has had the direction of works in various parts of Ontario and Quebec. In 1893 this company engaged him as consulting engineer, and afterwards he had full charge of the work both in the mine and in the construction of the mill. Mr. John P. Williams, the captain of the mine, had been employed by the company for five months. He informed me that he had been engaged for 20 years mining in England, and since coming to Canada 8 years ago he had been constantly working in mines in different parts of the province. Mr. William Nichol was superintending the prospecting department and Mr. E. D. Ledyard was the company's secretary at the mine.

Developing the property.

A working shaft 8 by 11 feet had been sunk on an east and west vein to the depth of 60 feet at an angle of 80 degrees, which was well timbered down for 22 feet to the solid formation. Above the surface the timbering continued for 6 feet, showing the shaft from entrance down 28 feet to a landing, where the shaft below was closed with a door. From this point a drift 4½ by 10 feet had been run in east of the shaft 26 feet, following the vein of ore. Below the trap door the shaft had been sunk to a further depth of 20 feet at an angle of 68 degrees, when it became vertical and was carried down a still further depth of 18 feet. The vertical part of the shaft being filled with water, measurements of it were not taken, and of course I could not observe whether it was sunk in ore or not. In the working part of the shaft above the trap door the ladder way had not been walled off from the part through which the ore was lifted, and I gave instructions to have this completed before any further hoisting was done. The middle part of the shaft was properly timbered. The vein varies from 4 to 6 feet in width, with hanging wall of chloritic schist and foot wall of talcose schist. The gold is disseminated through the vein of quartz. The ore is raised by a horse power derrick in buckets with timber guards, dumped into a car and conveyed over a tramway into the upper part of the mill, a distance of 100 feet eastward from the shaft. The trestle tramway is also continued in a westerly direction for the distance of about 600 feet from the shaft to a point known as the Burnt Knoll, on which the quartz vein crops out and where several surface openings had been made from which a considerable quantity of milling ore had been taken out. The elevated tram road required railing put on both sides, which I directed should be done. About 50 yards west of the Burnt Knoll another small mound occurs where gold bearing quartz was discovered at the surface, on which several test openings had been made with excellent showing of ore. The extensive area over which the ore-bearing rock crops out and the several test workings, together with the quantity of good grade ore now in sight in shaft No. 1, would apparently confirm the view that a large body of valuable ore exists and is easy of access on this property. It may be of interest to note several other discoveries to which Mr. Nichol, the prospector, called my attention. (1) North of the mill about 50 yards, where only a few shots had been put in, there was good showing of sulphurets and free gold. (2) About 100 yards still further north another discovery of sulphurets and free gold had been made, and the quality proved to be good by panning the former and crushing the quartz. (3) On the westerly part of the lot several veins have been uncovered, one showing the grade of ore as high as $22 per ton in the assay. (4) Recently, in addition to several others of less importance, Mr. Nichol discovered a large vein running north and south, on which considerable stripping had been done, showing excellent results both as to quantity and value of the ore carrying free gold.

The mill and its equipment.

The mill is a frame building 66 by 28 feet with a wing for boiler and engine of 41 by 16 feet. The height is 23 feet, with drop to the floor of 7 feet. Total elevation 30 feet. The machinery consists of a boiler 48 h.p., engine 35 h.p, a Northey pump to supply water tank of 4,000 gallons at the west end of the mill, the water being taken from a temporary reservoir the distance of 350 feet, and a Huntington gold mill. As the ore is conveyed into the upper part of the mill it is dumped over the grizzly. The coarse ore is then shovelled into a No. 2 Dodge crusher of capacity ranging from one to three tons per hour. Thence it passes into a rotary screen of half-inch mesh and the outfall goes into an elevator which returns it again to the crusher. The screened ore falls into a conical bin, and thence passes through the Tulloch automatic ore feeder, which supplies the 3½ foot Huntington centrifugal roller quartz mill in which it is pulverized to pass through a 60-mesh screen, when it is received on three copper amalgamating plates each in succession, and from these the pulp passes into a trough with riffles and down into the button feed to the Golden Gate concentrator, where the concentrates are saved and the tailings pass out into the waste screen. The mill was started in my presence for the first time and the machinery worked smoothly, but its efficiency could not be determined until fairly tested by treating a quantity of ore. Mr. T. D. Ledyard, the president and managing director of the company, states in a recent letter:

"The Huntington mill which we have is unfortunately a second hand one of the smallest size, and has been continually breaking down and giving us a good deal of trouble, but we have now got it repaired and trust that it will work steadily. We are however getting a new 5-foot Huntington mill from Fraser & Chalmers, of Chicago, which we hope to have in operation shortly, and the capacity of the two mills should then be 20 to 25 tons of ore per day.'

Supply of ore and cost of mining and milling.

In submitting a report to the company on the supply of ore and cost of mining and milling the same, Mr. F. Straith Miller, M. E., says: "From the points already developed there will be no difficulty in keeping the mill supplied even if the capacity is increased three-fold, and as there are several other good veins on other parts of the property the future of these mines in regard to ore supplies can be looked upon as assured. I consider that there is enough ore in sight to keep the present mill going for several years, and it is only a question of men and money and power to open up and develop these and other rich veins which exist on the property, and thus increase the output to any desired extent. The cost of mining the ore, picking and tramming to mill, will not exceed two dollars, and probably when the open cut on the knoll is more advanced this will be much reduced. The cost of milling 15 tons per day I estimate at about 80 cents per ton, and if the mill capacity is increased to 50 tons per day both the milling and mining should be done for less than $2.50 per ton." But experience makes one cautious in accepting roseate estimates of gold properties at par value. It will be time enough to speak sanguinely when a much larger amount of developement work has been done.

Employés.

At the date of my visit 14 men were employed and the large boarding house constructed for the Belmont iron mine on the adjoining lot, and about half a mile from the mine was being used for boarding and lodging the workmen and for the clerk's office. In addition to the blacksmith shop, a mine office and assay room 30 by 12 was in process of erection, and a summer shanty capable of holding 16 to 20 men and a mining captain's shanty have been built.

Idle properties.

A number of gold properties formerly worked in the region of the Lake of the Woods as well as the Belmont, Crescent, Pierce, and Richardson gold mines in the vicinity of Marmora, have remained idle throughout the year.

On July 13th I visited the Marmora mill, known as the Walker-Carter process for the treatment of arsenical and other refractory ores. For a full description see the Director's report of the previous year.

The Walker-Carter process.

Mr. George E. Keith of Toronto had rented the mill and recently formed a company known as The Marmora Reduction Company with a capital stock of $24,000, of which he retained $15,000. The mill had been idle for a length of time except the department to recover the arsenic, which had been running for a few weeks previous to this date. About 8 tons of pure arsenic were on hand, and the total output since the mill started was about 20 tons; the commercial value rated in Montreal from $65 to $70 per ton. The new company intend to run the mill part on custom work, drawing supplies from the neighboring mines. A contract had been made for the delivery of 1,500 tons of ore. Mr. Keith informed me that the mineral contained in the mispickel ores in the Hastings region averages about 25 per cent. arsenic. The mill it was claimed would save from 85 to 90 per cent. of the gold contained in the ores. The plan of operating the mill will offer excellent opportunities to prospectors or parties desirous of working their mines without large capital. Ores brought to the mine would be treated at fair rates and the products of the mines could be immediately utilized for further development.

SILVER.

Mr. Peter McKellar of Fort William writes that the silver mines in Thunder Bay district are still lying idle, but there is some prospect that the Lily of the Valley may be operated again in the coming spring. In this connection I have taken the liberty of inserting a paper prepared by him relating to the silver bearing district of Thunder Bay which was read at the recent meeting of the Ontario Mining Institute held at Kingston.

The silver bearing district of Thunder Bay.

" A few years ago the silver mines of Thunder Bay were in active operation and much mining development was in progress; now all are closed down. The depression in the value of silver, occurring about the same time that a number of the prominent mines had penetrated down into the silicious or poor-bearing stratum of the Animikie rocks, resulted in the complete closing down of all the mines. Of course in time some of them will be reopened; not all, as many mines were started without a showing to justify work, as is generally the case in all mining districts. Other new discoveries will undoubtedly be made here, as there are lots of unexplored areas under cover of drifts and alluvial deposits, etc.

The Animikie formation.

" It was known to geologists and mining men for many years that the veins were richer in silver within the argillaceous stratum than within the underlying silicious stratum; but few of the mining men had much knowledge of the thickness of either, and were often disappointed in their mining operations on this account. As this characteristic is becoming better understood, many of the misdirected efforts of the past may be in future avoided. At Thunder bay the Animikie group of rocks covers an area of more than a thousand square miles. It consists principally of slaty beds, argillaceous and silicious, lying nearly horizontal upon the upturned edges of the highly inclined Archæan strata, which in this locality undoubtedly are largely Huronian schists. The thickness of the Animikie formation along the run of the western belt of silver mines, or from Silver harbor to Gunflint lake, 80 to 90 miles, will probably average 600 to 1,000 feet; but out towards the coast line it will be much thicker. The silicious or lower stratum, the lower silicious division of Mr. Ingall, is at the base of the Animikie rocks, and is about 400 feet thick at the Duncan mine and nearly 700 at the Beaver mine. It is not likely to exceed the latter thickness much anywhere along the northern silver belt. The carbonaceous slaty stratum that overlies the silicious stratum shows a thickness of about 300 feet; but along the northern silver belt it has been partly or wholly removed by erosion and denudation in places; and in others it is covered with a bed or sheet of trap which, again to the southward is overlaid with slaty beds higher in the formation. In the mines along this belt all the rich deposits of silver were found in the veins within this argillaceous stratum, which in the southward direction dips under higher beds of the formation.

"It remains to be proven whether or not the argillaceous beds of the higher horizon have the same favorable influence on the deposition of the silver within them as the lower stratum has. From the past showing it would appear not, as in the great central belt, some ten miles or more in width, which lies immediately to the southward of the northern silver belt no rich silver lodes have yet been found like the mines on the western silver belt. This apparent barrenness of the central belt may be accounted for in two ways. First, that the lower argillaceous stratum is the real silver bearing stratum of the formation, in which case the veins here would have to be mined down through the overlying beds to reach the silver bearing stratum. Secondly, that the western silver belt seems to lie along a line of weakness, where there are many fissure veins, while along the central belt the veins are comparatively few and may not penetrate to the metalliferous reservoir to which I will refer further on. I consider the search for the causes that produced these silver-bearing veins a matter of much importance; that is, to try and find out if the silver in the veins is due to lateral segregation, or if it ascended in the fissures from a deep source, to be deposited subject to the laws of attraction or to the influence of the adjacent rocks. If the infilling is by lateral segregation it seems to me clear that in the Animikie group the veins need only be worked down to the lower silicious division, for the underlying Archæan strata are exposed in extensive areas here and there throughout the Algoma district. They show to be auriferous in many places; yet they do not show to be argentiferous in this respect anywhere, I believe, excepting in the vicinity of the great lake Superior trough, as at the Gopher and Star mines, Whitefish river, north of Whitefish lake, at the 3A mine north of Silver harbor, at the Cyrette location east of Nipigon bay; at the locations at the mouth of the Steel river, and at the Little Pic silver mines, west of the Little Pic river. These are all in the Archæan strata and carry silver ore similar to that of the Animikie veins; and in the case of the 3A and Gopher mines, rich ores. If the infilling is from below, we may look for these veins to prove valuable for mining to great depths, as the 3A mine and Gopher, etc., prove that some of the Archæan strata at least have the influence to cause the precipitation of silver in fissures within them when present in solution, as well as the argillaceous slates of the Animikie have. The greater showing of silver in the Animikie veins than in the Archean may be on account of the Animikie area occupying the more favorable position in relation to the metalliferous reservoir below.

Source of the silver ore.

"There is no doubt the Thunder Bay silver veins are true fissures, as shown by the faulting of the walls. The Silver Mountain vein shows a fault of 60 to 70 feet; the Beaver vein, 15 feet; the Rabbit Mountain much greater; the Duncan mine vein 120 feet etc.; so that the fissures must penetrate to a great depth. It seems certain that the copper and silver of the native copper mines of lake Superior were ejected from great depths with the fluid rocks of the Keweenawan group, and also that the fissures of the silver veins here resulted from the subsidence in cooling of these great eruptions, and subsequent to the flow of the fluid rocks. The previous fissures formed were filled with fluid rock and show now as trap dykes in great numbers, especially along and near the coast. It is highly probable that those fissures cut down to the great reservoir from which the eruptive rocks of the Kewcenawan were ejected; heated vapors, steam and aqueous solutions would ascend in the fissures, and carry metals and minerals along; and continue the ascension and precipitation of the solution subject to the influences of the adjacent rocks until the fissures were filled as we find them. In the event of the argillaceous beds having a greater influence in depositing the silver than the interstratified silicious beds that the Animikie have, the veins within the former should show richer in silver than within the latter, as we find them. So also with the underlying Archæan strata, it is quite probable that the veins will be rich in silver within some of them and poor within others in a similar way. The middle of the lake Superior trough, the portion opposite Thunder bay, appears to have been the most metalliferous part of the great reservoir, for all the great copper mines are here on the one side and the silver mines on the other. Although the rock formations continue westward for 200 miles or more, the rich mines do not show excepting around the middle portion of the trough.

Faulting of the vien walls.

"There are two series of fissure veins here; those of the most numerous nearly east and west, about parallel with the great trough; those across, prominently developed along the outer coast line, and rarely penetrating far inland. The position of the latter series near the middle of the trough, might be expected to prove richer than the other series of veins. The Silver Islet vein is one of them, and is certainly the richest one known thus far. If it can be proven satisfactorily that these veins carry the silver in the underlying Archæan strata, this locality is likely to prove a valuable deep mining district. I consider it quite probable that it will do so in view of the natural conditions that bear on the matter, some of which I have in this paper endeavored to show."

Two series of fissure viens.

COPPER AND NICKEL.

Mr. Joseph Cozens of Sault Ste. Marie states that no additional developement work has been done on his mine on Michipicoten island since the report of the Royal Commission on the Mineral Resources of Ontario, 1890. The excellent outfit of buildings and plant at the mine are kept in good condition. In July last the water was removed and the mine was thoroughly explored by Senator Pascoe of Michigan, the gentleman who opened the celebrated Calumet and Hecla mines, and who has had charge of the Republic mine for the past 21 years. He made a favorable report upon the property, and Mr. Cozens anticipates that a syndicate will be formed at an early date and that the mine will be operated again.

Michipicoten island.

A conglomerate lode has been discovered in the stratified formation on the west end of the island, about a mile and a quarter west of the old workings. It is 20 feet in width and has been opened to the distance of 4,000 feet, with cross cuttings showing good ore. Two bands of excellent sandstone of about one foot in thickness each have been uncovered.

Exploration work at Point Mamainse.

Early in August, when at Sault Ste. Marie, I met Captain T. H. Trethewey, who has had charge of the work in the mining locations of the Copper Creek Mining Co. at Point Mamainse. Mr. T. advised that as the work then being done on the property was so very limited and of such a diversified character, but little could be gained by going over it at this date. About a dozen men were employed in groups of two and three, doing exclusively exploring work. Work had been suspended on the main shaft, which was then nearly filled with water. Its total depth was 308 feet, at an angle of 57 degrees east, and it was properly cribbed from surface down to the solid formation. Besides the drifts at 80 feet from the surface previously reported, another at the bottom of the shaft had been extended southward for some distance, in which chambering had been done for a reservoir. The other workings consist of cuts and shafts, over 100 in number, varying from a few feet to 48 in depth and extending in different directions over an area of about 4,000 acres. The shafts were properly covered when left, and in those where valuable ore was found in considerable quantities work would be resumed in the future; the barren ones were entirely abandoned. Most of these openings at this date were filled with debris or water. In a recent letter Captain Trethewey writes: "All operations at Mamainse were closed a short time after you were here (Aug. 2), a few feet of drifting at the bottom of the shaft (308 ft.) were done, making a total distance from the shaft of 100 feet. This is about all the change made." For a complete description of the property see the Director's exhaustive report for 1893.

Copper Cliff Mine.

On March 12th work in the Copper Cliff mine was confined to sinking a new shaft at an incline of 77½ degrees, starting in the old shaft at the third level, the object being to reach the deposit of ore at the deepest part of the mine without having to run in drifts at so great a distance as that required from the old shaft, which has an angle of about 40 degrees. The continuance of the large deposit of ore at this depth offered a sufficient reason to make the outlay for the new shaft. It was also intended to sink the new shaft below the seventh level to a sufficient depth to open up the body of ore on the eighth level. Much time and expense would be saved in tramming the ore the shorter distance to the hoist. At this date the new shaft had reached the fifth level, and the greater part of the force of 38 men then employed were engaged in timbering this part of it. The work was being neatly and skilfully done under the direction of Captain Davis, and with due regard to the safety of the workmen. On the completion of the new shaft the old one would be abandoned for working purposes from the third level down. At the depth of the seventh level the ore deposit was 95 by 150 feet.

Sinking a new shaft from the third level.

Roasting the ore.

One smelter was running at this date and treating about 100 tons of ore daily with a force of 60 hands; 20,000 tons of roasted ore were on hand, and the contractor stated that the following week 4,000 additional tons would be calcined, and about 1,600 the week after. Mr. Trist had 55 men on the roast yard at this date. The work was being carefully managed.

Second inspection.

My second inspection of the mine was made August 10th, when a few days were occupied in examining the work both in the mine and the outside departments. The management was the same as at my former visit. The total force of 51 men were employed at the mine at this date, 31 of whom were on underground work. There was also an additional force engaged at the smelters and roast yard and other outside work. About 150 tons of ore were being mined daily.

The Inspector's Book.

As I had been supplied with an Inspector's Book and wished to make the entries of the work done in the mine as complete as possible, considerable time was spent in taking measurements and securing an accurate description of the whole work up to date. Captain Davis gave to me his undivided assistance in doing this work. We obtained valuable aid by the use of some of the tracings of the work made by recent surveys of the mine. The old shaft, 8 by 16 feet, had been sunk to the depth of over 500 feet at an incline of 40 degrees. Shaft No. 2, or new shaft, 8 by 17 feet, with incline of 77½ degrees, starts from the third level in the old shaft at 150 feet from the surface. The distance in this shaft on its incline from No. 3 to No. 4 level is 50 feet; from No. 4 to No. 5 level, 51½ feet; from No. 5 to No. 6 level, 56 feet; and from No. 6 to No. 7 level, 54 feet. The shaft was also continued below the seventh level to the depth of 35 feet at this measurement, and sinking was still going on. Total depth of shaft at incline at this date, 396½ feet. This shaft was substantially timbered and the ladder way with short rests properly divided from the hoisting part, and all was in excellent working order down to the seventh level. On examining the part of the shaft below this level I found the formation firm, and the walls were carefully trimmed as the work proceeded. Solid pentice timbering gave safe protection from the work above.

Measurements of the new and old shafts.

The old shaft is on an incline of 40 degrees. From the surface to level No. 1 is 58 feet. At this level a drift has been extended west 110 feet, another southeast 200 feet. There is a stope east of the shaft 40 by 50 feet and a cross-cut 40 feet. From level No. 1 to No. 2 is 40 feet. A drift northwesterly from the shaft has been run in 100 feet, with a cross-cut of 36 feet out near the end. The stope on the east side of the shaft is 15 by 30 feet. The depth from No. 2 to No. 3 level is 83 feet. A drift has been run in west 50 feet, which thence turns north 75 feet and a cross-cut of 25 feet at the point of the angle. A drift was also extended east of the shaft 50 feet and turns north 55 feet, thence east 75 feet, with a stope at the back end 30 by 40 feet. From level No. 3 to No. 4 is 82 feet. The drift northeast of the shaft extends 150 feet with a stope at the back end 30 by 50 feet. A cross-cut at 75 feet from the shaft extends northwest 75 feet. From No. 4 to No. 5 level the depth is 65 feet; a drift starting east of the shaft and circling northward was driven in 50 feet, thence angling northwest 100 feet. At 40 feet from the extremity is a cross-cut of 40 feet. From the fifth to the sixth level the depth is 87 feet. In this level a drift starting northeast from the shaft circles to the north and is driven in 300 feet. From the sixth to the seventh level the depth is 86 feet. A drift east of the shaft and northward has been run in 335 feet, extending 40 feet north of the new shaft with a stope of 40 by 90 feet. The distance from the new shaft to intersect the body of ore is 40 feet, while in the old shaft the distance is nearly 300 feet. A stope from No. 2 level extending downwards to the floor of the fifth level had been made and pillars were left as supports. This stope was being continued to the sixth level by removing the floor of the fifth, leaving the pillars remaining. This extensive opening is smaller at the top and widens to the extent of 100 by 110 feet at the sixth level. A winze had been opened between the sixth and seventh levels and on the floor of the seventh level a large quantity of ore had been shot down preparatory to hoisting. In addition to the day and night shifts in sinking the shaft, a considerable force of workmen were employed in the fifth and sixth levels in removing ore.

Precautionary measures.

As these were the principal places of working at the date of my inspection, I spent considerable time in company with the captain and underground foreman in carefully looking over the work as then progressing, which presented a satisfactory appearance. Constant changes however would occur as the work proceeded, but the captain stated that each gang of men after blasting scaled the walls in the vicinity of their own work, besides which a few good men were sent into the mine every Sunday at midnight, when the mine would be free from smoke, and were occupied until seven o'clock Monday morning in making a general survey of the different places of working, and all rock presenting any dangerous appearance was removed. Suitable appliances, such as ladders, ropes, etc., were kept on hand for this purpose.

Machinery.

The machinery in use at the mine consists of a hoisting engine, air compressor, 80 h.p. boiler, double drum hoist, three pumps, and rock breaker, with boiler and engine. Five drills were being worked and two skips were in use.

The smelters.

The smelters were running at their ordinary capacity, and employed the usual force of workmen. A new cupola had just arrived and would soon be put in place, while one of the old ones would undergo repairs. The matte was not being bessemerized at this date. At No. 1 smelter there were two boilers, one engine, one Baker blower, one water-jacketed furnace and water-jacketed wells. At No. 2 smelter are one engine, one Baker blower, one water-jacketed furnace, and water-jacketed wells. The boiler at No. 1 is used for both smelters. The bessemer plant is made up of one cupola, one blowing engine, two boilers, three rotary converters, three hydraulic cylinders for revolving converters, one rock breaker pug mill, one hydraulic elevator, one hydraulic pump and one supply pump.

The company own a good diamond drill outfit, which is occasionally used for exploiting by boring.

The roast yard.

A large supply of ore, roasted or in process of roasting, was on the roast yard and Mr. R. W. Trist, the contractor for this department of the work, informed me that he usually employed from 70 to 80 men roasting and delivering the ore at the smelters. The work was being carefully and properly managed. The engineer accompanied me over the trestle railway track, which I found in excellent condition.

The following note was entered in the Inspector's Book at this date: "I found the mine in a much improved condition and being carefully worked under the direction of Captain H. Davis. It is well ventilated and apparently in a safe condition. The machinery at both mine and smelters, as well as the bessemer plant, was in good order and safely protected from danger to the workmen."

Third inspection.

On September 22nd I again visited the mine on the occasion of an accident which occurred on the 15th by the fall of rock from the roof of the seventh level, proving fatal to two of the workmen and slightly injuring another. I spent considerable time in the mine at that date, but more particularly in examining the cause of the accident, a special report of which was made to the Commissioner of Crown Lands. The killing of the unfortunate men I regarded as entirely accidental, and the coroner's jury at the inquest took the same view of the occurrence and attributed blame to no party in connection with the mine. For the time being all work was suspended in the mine, but would be resumed shortly. The captain fully concurred in my direction that the entire roof of the level should be scaled before further work was done in it. Operations had been continued in the same parts of the mine as when I visited it the month previous, and its condition, except the advanced stages of the work, had not much altered. The day and night shifts had been constantly engaged in sinking the shaft, and at this date its depth was about 75 feet below the seventh level.

Investigating a fatal accident.

Progress of operations.

I received in December notice of work closing, except for exploring and fitting up the mine for winter. Captain Davis in a recent letter informs me that the stope between the sixth and seventh levels had been broken through, and that the ore in this part of the working would be removed by spring. The new shaft was sunk to the eighth level, 93 feet below the seventh. He writes: "We have it well timbered that far down and skips running in good shape. We have our drift in at the eighth level towards the ore body about 30 feet. The pentice is in below the eighth level, and we are now sinking towards the ninth level and have reached a depth of 44 feet from the eighth level, or a total from the seventh level of 137 feet. We are sinking a winze in the seventh level on the ore body to intersect the eighth level to secure proper ventilation and to aid in stoping." The winze at the time of his writing was down 50 feet. The week previous a new steel cable had been put in the west part of the shaft, as the old one had become too short.

Granulated slag.

Manager McArthur informs me that no additions of any kind have been made to the smelters or roast beds. The granulated slag dumps are assuming large proportions. "The slag granulating system works like a charm," he writes. No. 1 furnace has been granulating its slags day and night, summer and winter, for the last eighteen months without a hitch of any kind, running out about 50,000 tons of granulated slag. No. 2 slag granulator and elevator started up on the first of June last and gave equally good satisfaction, having since then run out about 18,000 tons of granulates. Practically the hardest, most fatiguing, and somewhat dangerous work of pot-hauling is now a thing of the past. There are now two elevated tramcar tracks stretching from the top of each elevator shaft for the distance of about 200 feet to the outer edge of the old slag dumps and these roadways are entirely covered in, roof and sides, for the whole distance as protection to the workmen. All the works are kept in a safe condition.

Two fatal accidents occurred in the mine during the year in addition to the one mentioned above. On November 24th Axel Johnson fell down a shaft and was killed. On December 10th a rock fell on the plank upon which William Martin, who was assisting in timbering the main shaft, was standing, and he was thrown down the shaft and received injuries from which he died two days afterwards. The accidents were of such a nature that I was not requested to make special reports upon them.

Official returns furnished by the head office show that this Company's mines produced from their opening up to December 1st about 400,000 tons of smelting ore, and 41,600 tons of matte, which is equivalent to 7,638 tons of refined nickel; but the whole of the ore has not been smelted.

Evans Mine.

First inspection.

At the Evans mine on March 12th the work was just being opened up, as operations had ceased in the fall previous and the mine had been standing idle throughout the winter. Work had been resumed only on the Wednesday previous to my visit. A total of 64 men were employed, 45 underground, some of whom were busy trimming walls and fitting up the mine in proper shape for work. Stoping to a limited extent had commenced in the second, third, fourth and fifth levels; also in the open pit; and about 125 tons of ore had been hoisted daily for the two or three days previous. A much larger quantity per diem would be taken out when the work became properly regulated. Seven drills were in use or being placed, and an additional one in the open pit. During the respite of regular mining work four test bores had been made in the deepest workings of the mine with the diamond drill of the respective depths of 35, 45, 55 and 115 feet. The holes had been plugged to prevent the inflow of water. The rock crusher had been started first the Thursday previous, and the ore was being prepared and hauled by cars to the roast yard at Copper Cliff, where the ore is roasted from the three large mines operated by the company. I found the mine in a fairly good condition, with the exception of a few places which were being put in order as expeditiously as possible. The machinery was in good running order.

Second inspection.

Measurements.

At the date of my second inspection (August 8th) I made a general survey of the work done up to that time, and made also the proper entry of the same in the Inspector's Book. The work consists of one open pit near the rock house, 96 by 106 feet and 100 feet in depth, and a vertical shaft 8 by 12 feet to the depth of 263 feet, with 10 feet of water at the bottom. No. 1 level at 50 feet from surface was driven in north, and has been worked partly out in an open pit. It still extends north of the open pit in unstoped ground 75 feet. On the south side of the shaft a stope has been made 25 by 25 feet with a raise of 30 feet. No. 2 level at 100 feet from the surface has been extended west 75 feet. No. 3 level is 48 feet below No. 2, and south and near by the shaft a stope has been made 34 by 97 feet with a raise of 30 feet.

In level No. 4, 57 feet below No. 3, north of the shaft an extensive stope 76 by 87 feet with a raise of 30 feet has been worked out, with substantial pillars left to support the roof. The fifth level is down 48 feet below the fourth and a stope south of the shaft 51 by 60 feet with a raise of 30 feet in the centre has been made; also there is north of shaft a stope 19 by 50 feet, with a raise of 25 feet.

From No. 2 level an underhand stope has extended down to No. 4 level. It is of small size at the top of the opening, but measures at No. 3 level 40 by 40 feet and at the floor of No. 4 level 42 by 49 feet.

Working force.

The work was under the direction of Captain Davis, with Mr. Thomas Hambly as foreman, who has been in the service of this company five years and at the Evans mine three years. The usual force of workmen was employed, and about 190 tons of ore raised daily.

Machinery.

The machinery used at the mine, which was in excellent condition, consists of a hoisting engine, compressor, four boilers, rock house engine, rock crusher and screens, three steam pumps in the mine, one cage, seven Rand drills and all other appliances required to keep up repairs, etc.

Condition of the mine.

The condition of the mine as well as the outside department of the work bore evident traces of careful supervision, and but little was required by way of direction for the safety of the workmen.

Stobie Mine.

In compliance with section 62 of the Mines Act I received notice from the manager of the Canadian Copper Company, under date of 21st July, that they were again operating the Stobie mine. On August 9th I visited the mine and made a thorough examination of the works.

Measurements

The open pit, 130 feet westerly from the rock house, 47 by 90 feet, had been sunk to the depth of 70 feet. There were 12 or 15 feet of standing water at the deepest part. There is a bench westward from the open pit and near the tunnel of 30 by 47 and from floor to surface 30 feet. A small stope has been made under the hanging wall of the west side of the pit extending back 30 feet. I directed that before further advance be made on this stope a substantial pillar should be left to support the roof. No work at this date was being done in this opening. A drift still advances westerly 120 feet, with a stope at the entrance 26 by 36 feet with a raise of 25 feet. At the west end of the drift the stope was raised to the surface, leaving an open pit work of 41 by 48 feet with a depth of 33 feet from the surface. There is a skip track at an incline of 30 degrees running from the top of the rock house down to the place of working in the open pit, a distance of 150 feet, and about 175 tons of ore are trammed out daily. A total of 56 men were employed at the mine, with 33 of the force on underground work under the direction of Mr. Samuel Bryant as foreman. Captain Davis, who has the supervision of the company's three mines, Copper Cliff, Evans and Stobie, accompanied me to the mine and assisted in taking the measurements of the work described.

Machinery.

The machinery consists of two boilers, one hoist engine, compressor, engine for rock breaker, screens and tables. Two skips are operated. There was a small compressor and boiler standing idle. The piston rod of the compressor required to be cased for safety, which I gave notice to have done, as well as suitable guards to be placed around the fly-wheels of the same. Otherwise the mine and machinery were in good condition.

Rock house.

On a careful examination of the spacious rock house I found that it was heavily laden with ore, and it showed slight indications of spreading, to which I at once called the attention of the captain of the mine and also of the master mechanic. The captain gave immediate instructions to have a much less quantity of ore kept on the crushing floor at a time in the future. The master mechanic, Mr. Greeg, informed me soon after that the building had been substantially stayed and that the casing and guards had been placed at the compressor as directed. Work at this mine closed down early in the fall.

Worthington Mine.

At the date of my first inspection of this mine (March 10) 70 laborers were employed, and about 75 tons of high grade ore were mined daily and shipped to the roast yard at Blezard. The mine was in a safe condition and the machinery used was in excellent running order and doing the work efficiently.

Second inspection.

The workings at the second inspection (August 6th) consisted of shaft No. 2 now in disuse except for ventilation, which was the first shaft sunk. It is 100 feet deep and is connected with the shaft No. 1 by a drift going west at a depth from surface of 70 feet. Shaft No. 1, at a distance of 100 feet from shaft No. 2, is 180 feet deep. Fifty feet down the first level is driven west 80 feet. Sixty feet below this level No. 2 is driven 56 feet west and 20 feet east to the second shaft for ventilation. Level No. 3 is 65 feet lower, or 175 feet from surface, and is driven 20 feet west; thence it turns and goes south 24 feet. Between levels No. 1 and 2 west a stope is being worked at this date about 20 by 35 feet. Stoping also has been done between shafts No. 1 and No. 2, but not to a large extent. The plant is composed of two steam boilers, air compressor, hoist, crusher and conveyor, two steam pumps and drills. The air receiver on the compressor required to have a covering to insure safety, and the fly wheels on the same to be protected by railing, which I directed should be done; also that the explosives should be taken into the mine in a covered cannister. Otherwise the mine at this date was in a safe condition and the machinery in good order.

Measurements.

Mining plant.

Seventy-two men were employed at the mine. Captain McBride had charge of the mine work, and Mr. Ian Cameron is still the company's general manager. A large quantity of excellent grade ore was being taken from the mine. Two to four cars were loaded daily, to be taken to the roast yard at Blezard mine, where ten additional men were employed. The week previous 23 cars of ore of 18 tons each, being over 400 tons, were shipped from the mine. About 16,000 tons of ore were on hand. The smelter at the Blezard mine had been standing idle since November last, but would be started up again as soon as the coke came down to near its former prices. At this time it was ranging $1.40 per ton dearer than formerly. About 20 tons were used daily when the smelter was operated to its full capacity, equalling a loss at present prices of some $28 per day should the smelter be run. At the date of my last visit to the locality the smelter had been started but a few days.

Output of the mine.

The following plant is used at the smelter: Locomotive, two boilers, engine, blower, water pump, water-jacketed smelter, with water-jacketed well.

The manager in a late communication says: "We stopped mining at the Worthington on the 14th of September, since when we have been smelting continually at Blezard."

Blezard Mine.

The Blezard mine, also owned by the Dominion Mineral Company, has been lying idle throughout the year.

Murray Mine.

I found the Murray mine at my first inspection (March 13) in a safe condition and the work progressing in the usual manner. No special changes had been made since my previous visit, except in the advanced stages of the work, a description of which is given below. About the usual force of laborers were employed, and a very considerable quantity of ore was being taken out daily and conveyed to the roast heaps.

The smelter.

Mr. Thomas G. Saunders had been acting for four months as foreman at the smelter, Mr. H. W. Edwards having decided to accept the offer of a more lucrative situation. Mr. Saunders had been previously foreman of the Orford Company's works at Constable Hook, N. J., for refining nickel and other ores, notably copper, and held his connection with that company for 15 years. A single smelter was running continuously and treating 100 tons of ore daily. All the matte is re-treated previous to the weekly shipments. A force of 80 laborers was employed, including mechanics, those employed about the roast yard and at general work. About 5,000 tons of ore, roasted or in process of roasting, were on hand. A large supply of coal and coke had been provided, and 7,000 cords of wood were in the yard. The smelter was in good order and running successfully.

Second inspection.

A second inspection of the mine was made August 8th, when a total of 140 laborers were employed at the mine and smelter. About 60 were at the mine, 45 of whom were on underground work, and about 80 tons of ore were mined daily. I secured as complete a description as possible of the entire work done in the mine up to date for entry of notes in the inspector's book.

Measurements.

There are three shafts. The one known as No. 6 is vertical, being the main shaft for pumping and hoisting. Shaft No. 4 is 112 feet northeast from No. 6, and is sunk to the depth of 56 feet and used at present for ventilation. There is also a stoped shaft northeast from No. 4, 305 feet. This was a test shaft and the open pit is 26 feet deep. The first level in No. 6 shaft is 56 feet from the surface. Stoping has been carried on northeast and west-southwest, extending along the strike northeast 200 feet. At intervals of 30 to 45 feet stopes 20 feet high have been opened out towards the hanging boundary. From foot wall to hanging wall the average width is 60 feet. Pillars 20 to 30 feet square supporting the roof also separate one stope from another. On the southwest side the same system exists, but the extension along the strike is 160 feet. No. 2 level in shaft No. 6 is 100 feet from the surface. Drifting northeast has been extended 160 feet. Two stopes 30 feet high have been opened out towards the hanging wall, leaving a width of 30 feet. A middle pillar 30 by 40 feet supports the hanging wall and floor of level No. 1.

On the southwest side drifting has proceeded 94 feet. At 25 feet from the shaft a stope 30 feet high, 30 by 30 feet, has been made. This side of the mine is at present idle.

Extension of work since my inspection in March may be summed thus: from the second level at a distance of 80 degrees northwest of No. 6 shaft a sub-shaft has been sunk to the third level and the northwest drift extended 10 feet. At the end of the northwest drift, second level, an advance of 20 feet. A rise is being put up to communicate with the first level. This rise is up 30 feet. Stoping at this date was confined to the ore body between the first and second levels.

Plant.

For drilling purposes five air drills are in use, driven by an Ingersoll air compressor at the surface. Hoisting is done by an efficient vertical steam engine near the rock house, where a Blake stone crusher is worked by a separate and adjacent engine for that purpose. A horizontal steam hoist has been recently fixed at the mouth of the sub-shaft for hoisting purposes. A cage and cars are used.

State of the mine.

The system of mining is especially adapted to the health and safety of the workmen. The roof of stopes is everywhere well arched. Captain Richards stated that frequent inspections were made for detection of any loose scales. Ventilation is well secured by connection of No. 4 shaft with No. 6. No. 4 is an up-cast. The collar of this shaft has lately been heightened several feet above the surface, so as to produce an improved and well-defined circulatory current of air.

The smelter.

The smelter on August 7th was running from 80 to 100 tons daily with about 40 laborers, part of whom were on the ore roast yard. The furnace is water-jacketed and the well lined with fire brick. The last well stood for five months, but usually the lining fails in about half this time. The material used for other lining purposes are fire clay and skimpings obtained from the old Bruce mines.

Bessemerizing the matte.

When smelted the molten matte of from 10 to 12 per cent. metal contents is drawn off into the converters and subjected to a cold blast which is forced into the mass under a pressure of 8 lb. to the square inch, and when the charge is sufficiently oxidized it is drawn out into pots and allowed to stand five or six hours for cooling. The refined matte, now raised to 70 per cent., settles by gravitation to the bottom and is easily separated from the slag at the surface. When broken off, if any portion of the slag is too valuable for the waste dump it is broken up and mixed with roasted ore, and passes again through the smelter. A car of from 18 to 20 tons of matte is shipped weekly. The boiler, engine and air compressor I found in good working condition.

About 7,000 tons of ore were on hand, roasted and being roasted. Twelve cords of wood were consumed daily, with a large stock on hand.

Trilabelle Mine.

The Trilabelle mine is on lots 10 and 11 in concession 3 of Trill, about 40 miles west of Sudbury. It is owned by a Duluth syndicate of which Mr. H. W. Wheeler is president. Mr. George W. Mann has had the management of the work, and he has employed from 20 to 30 laborers for a part of the season. Besides sinking a shaft 60 feet in depth and doing some other developement work, a good road of easy gradient has been made out to the mine from the Travers mine owned by the Drury Nickel Company, thereby forming a connection out to Worthington, a distance of about 13 miles. The ore body I am informed has been tested to the width of several hundred feet, and is of high grade and easy of access. When I was visiting the other mines in the locality work in this mine was suspended and the shaft was filled with water. The working force was engaged in constructing the road and doing other outside work preparatory to more extensive operations.

Developement work.

The property owned by the Drury Nickel Company, known as the Travers mine, has been lying idle during the year. The Beatrice mine has also remained unworked.

Properties idle.

IRON.

On August 3rd I drove out ten miles west of Ottertail to the old property generally known as the Stobie iron mine, which is in the township of Coffin, near Desert lake, and which was then being tested by drilling to prove the extent of the deposit of iron. It is nine miles north of Stobie station and about 35 miles east of Sault Ste. Marie. A railway charter was obtained last year by the Portlock & Desert Lake Railway Company to construct a road from Portlock harbor, near Stobie station, to the mine, a distance of ten miles. The property comprises Y8, 157 acres; A2, 320 acres; A1, 357 acres. Total, 834 acres. Mr. James Stobie retains a tenth interest in Y8, and the remainder of this section, together with the other two, are owned by the Cleveland Rolling Mills Company and Mr. George Rankin. Mr. Stobie operated this property several years ago by sinking test shafts, when a limited quantity of the ore was shipped to Detroit and the test by smelting proved the ore to be of good grade and free from impurities. Should the ore body be found by the present test borings in sufficient quantity, it is then intended to erect a smelter at the harbor for its treatment.

Prospecting with a diamond drill in Coffin township.

A suitable outfit for doing the work had been brought on the ground some time previous to my visit, but a delay in obtaining the diamond drill had permitted only a few days' work to be done up to that date. One bore had been put down on Y8 to the depth of 56 feet without favorable results, and the plant was then being removed about 1½ miles east near to the place where the deepest shaft had been formerly sunk. The bore at this point will be sunk at an angle of 45 degrees and to a depth of from 300 to 500 feet.

A boiler of 15 h. p. was being used, and also a Sullivan drill with capacity to bore 500 feet, the diameter of bore being 15-16 of an inch. The outfit had been purchased from the United Bessemer Mining Co. of Michigan. A Cameron pump with 400 feet of piping was on hand.

The work was under the direction of Mr. Alexander McKee, an old miner, and Mr. George Rankin, who was at the works. Mr. Rankin has engaged Mr. Frank Newett, recently from the Ashland mine, Michigan, to do the drilling. A comfortable boarding house with stabling and other necessary buildings had been provided, and five laborers were employed.

Mr. T. D. Ledyard of Toronto writes of recent date as follows: "The Belmont Bessemer Ore Co., 29 Broadway, New York, who have leased my

Belmont Bessemer Ore Company.

property known as the Belmont iron mine on the west half of lot 19 in the first concession of Belmont, are making arrangements with the Cobourg, Northumberland and Pacific Railway to complete the railway from the iron mine to the Canadian Pacific Railway, and when completed the C. P. R. will operate it as part of the Cobourg Railway, which they have leased. The Belmont Bessemer Ore Company expect to supply the Hamilton Furnace Company with a considerable amount of their magnetic ore."

BARYTES.

Testing the McKellar island mineral.

Peter McKellar of Fort William in a recent letter favors me with the following items of information respecting the barytes lode, on McKellar island, in lake Superior: "The mine has been purchased by Messrs. Barnes & Upton of Duluth, and a payment made. They have been testing the ore, and several hundred tons have been used with good results. Manufacturing works have been erected in Duluth, and it is expected the barytes mine will be extensively worked next summer."

GYPSUM.

Paris Mine.

My first visit to the Paris gypsum mine, which is situated on the north side of the Grand river about 1½ miles east of the town of Paris, was made on May 10th. Mining had been carried on constantly throughout the winter and spring by a force of three workmen, who took out from 4 to 5 tons daily by contract. This mine was in a very unsafe condition at the date of my last inspection, and I gave directions to have some parts of the drift refitted by placing new stulls in the dangerous places with good flagging overhead. This however was not done, and just a day prior to my visit a part of the drift crushed in. Fortunately this occurred in the night time, after the men had left the work, and thus they escaped being entombed. It was now decided to run in a new drift to the gypsum layer, commencing at a point east of the old one, and to construct it of sufficient size to admit of the use of a horse or mule to haul out the plaster. Timbers at this time were being brought on the ground for supports to the drift, and day and night shifts would be worked until the ore was reached at the supposed distance of about 125 feet from the entrance. When completed mining would be continued with about the same number of men. The class of gypsum is similar to that formerly reported.

Plaster and alabastine mill.

About 500 tons of plaster had been received at the Paris mill during the present year up to date on a contract for 1,000 tons from the Adamant Company's mine, near Cayuga. The manager, Mr. Wheeler, informed me that another 1,000 tons besides the present contract would be required from this source to meet the demand for the year. Besides a large quantity ground for fertilizing purposes, a very considerable amount of calcined plaster was prepared, the demand for which had greatly increased. The alabastine manufactured at the company's mill, the only place of its production in Canada, has met with a ready sale. Also the potato bug finish, put up in barrels of

350 lb. each, has been distributed largely throughout the country and has become generally used as an effective agent in the destruction of the Colorado beetle, while its fertilizing qualities are valuable to the crop. The mill, which had been running both day and night for some time past with an increase of workmen, was in good running order.

Second inspection.

On my second inspection of the mine (December 21st) I found the new drift, 450 feet east of the old one, substantially constructed. It had been driven in 171 feet due south, when it intersected the layer of gray gypsum from four to five feet in thickness. It was continued in the same course along the bed about 100 feet, opening up a fine face of mineral on the west side of the drift. Three men were working in the mine, removing from three to four tons daily by contract at $1 per ton, and were placing it in the ore shed at the mouth of the drift. Thence it is hauled a distance of 1½ miles to the mill in the town, where it is ground as land plaster.

The mining had been carried on for three months previous to my visit. In the former part of the year about 750 tons had been taken out through the old drift, when the work ceased by reason of the falling in of the roof. I found the mine at this visit in a greatly improved and safe condition.

Eight hands were working in the mill. The plaster, of which there was a large stock on hand, was being ground for land use. A new buhr-stone was being placed for grinding gypsum for alabastine, of which the sales during the present year had been larger than in any former one. About 2,200 barrels of potato bug finish had also been disposed of.

Mr. T. W. Wheeler had still the management. Mr. R. E. Hare had charge of the milling, and Mr. John Ray was employed as millwright.

Martindale Mine.

The Martindale mine has been worked by two men for about five months during the year, and about 200 tons of gypsum taken out. The work is done by contract. The day I was at the mine it was idle, and but little change in its condition was apparent since my former report.

Excelsior Mine.

Excelsior mine, which is 2½ miles east of Cayuga, had been worked up to August with four men, and about 1,000 tons of gypsum had been taken out; 500 tons were still remaining at the mine, and since that time no work had been done at it. Since the former report describing the work a drift has been run in at the foot of the incline, west 50 yards. In the drifts there are tram tracks laid near the face of the layer of gypsum, and as this is removed for several feet back tracks are relaid nearer the gypsum, and the open space is walled up with waste rock to support the flat roof. The mine (December 19th) required to be carefully refitted before work was resumed to make it safe. Mr. T. A. Nelles, who has charge, promised that this should be done, and timbers were then being brought on the ground for the work. Since then he has reported to me that the refitting has been completed, and asking that I would again come down and look over it.

Teasdale Mine.

After about 75 tons of ore had been taken out of the Teasdale mine all work in it was abandoned on account of the inflow of water, and from this cause it may not be worked again. There was a large body of gypsum exposed.

Garland Mine. On December 20th Mr. Henry Wilkinson had charge of the Garland mine, and two men with him were taking out about five tons of ore daily at a cost of $1.35 per ton. As formerly, the gypsum is carted to Caledonia and ground for land use. At the bottom of the incline, which has been run in westerly from the surface 100 yards, the gypsum bed is reached, and a drift in a northeasterly direction has been run in 50 yards to the present place of working. The drifts vary in their courses in all the gypsum mines as the work progresses, the old ones being filled as new ones are opened. An area of from two to three acres has been worked over in this mine, and labor was confined at the date of my visit to working out a large pillar of ore which had been left standing as a support, and which would require about one month yet to accomplish.

Several years ago a shaft was sunk 65 yards northeast from the mouth of the present working drift, where a layer of gypsum was reached of from five to six feet in thickness, and it was intended as soon as the pillar was removed in the old workings to open an incline drift to reach this layer of gypsum, the extent of which has not yet been fully explored. After holidays it was expected that a larger number of workmen would be employed.

The condition of the mine was somewhat better than at my former inspection. The old workings however will soon be abandoned, as the ore is nearly exhausted.

Gypsum discovered at Caledonia.

It may be of interest to state that while visiting the boring for natural gas in the town of Caledonia, which was being driven down on the north side of the Grand river for Mr. Robert E. Walker of that place, a discovery of gypsum was made. On this well the boring was down 65 feet at the time of my visit, December 20th, although 20 feet additional was sunk that day. At a depth of 40 feet from the surface the 8-inch bore passed through a layer of white gypsum four feet in thickness, and at the depth of 59 feet a thin layer was pierced of very pure white gypsum. The bore was in common limestone, from 20 to 25 feet from surface.

Borings for natural gas.

At a depth of 380 feet it was expected to strike the Clinton formation, which is composed of a layer of limestone about 20 feet in thickness, and a layer of slate or shale 10 feet in thickness. Then follows the red Medina sandstone of 40 feet in thickness, below which is a layer of slate of 50 feet in thickness and the white Medina sandstone of 15 to 20 feet in thickness. Sometimes gas is obtained in this formation. Beneath the Medina is the Hudson River shale, which averages about 700 feet in thickness. These formations, I was informed by Mr. Carmody, who was employed in sinking here, apply to all the places where bores have been put down. At a depth of 100 feet the Niagara limestone was reached, which is here about 240 feet in thickness, and in this formation in places there was a liberal flow of strong brine. The best flow of gas in the wells sunk in Caledonia is from the Clinton limestone. Three wells had been sunk: one 500 feet, with 90-lb. pressure; one 550 feet, with 240-lb. pressure; and one 350 feet, with 90-lb pressure. The third was not completed at the date of my visit. The first two wells were sunk by contract at $1,500 and $1,200 respectively. The demand for natural gas here was greatly beyond the supply of the wells. One furnace and about a dozen stoves, with a few burners, were being supplied.

I have the honor to be, Sir,
Your obedient servant,
A. SLAGHT,
Inspector.

WATERFORD, March 13, 1895.

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